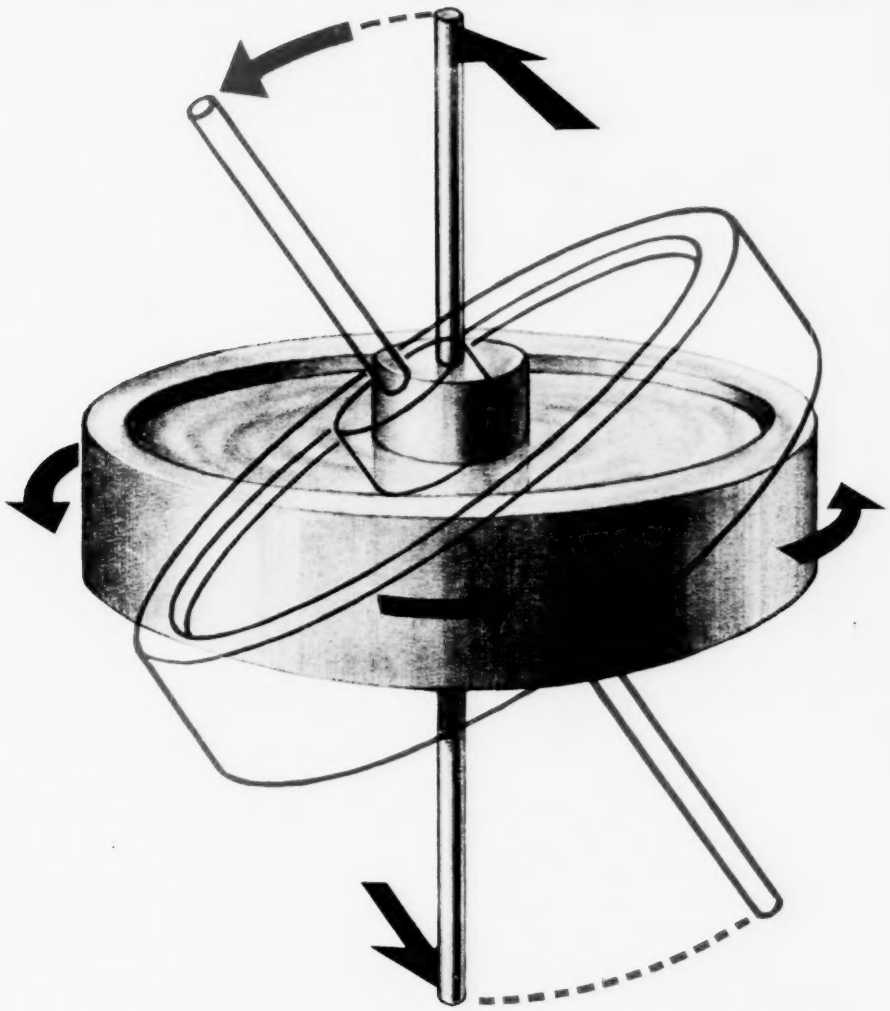
INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SCMA • SIMULATION COUNCIL NEWSLETTER



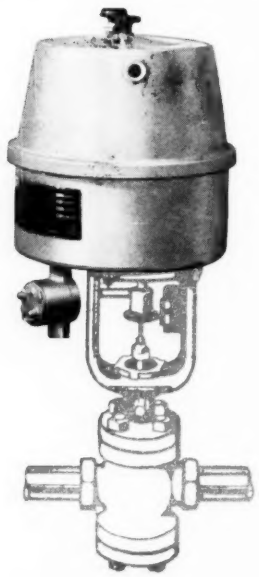
in this issue:

JUNE 1960

Ring Codes 954
The Gyroscope 958
Mass Flow Measurement 966
Electronic Control of Pipelines 972
Process Control Systems 984
Welded Thermocouple Junctions 988

Electro-Hydraulic Valve Actuators

by **GPE Controls** offer the simplest, most compact, lowest-cost way to operate control valves from an electric signal. Model 698 shown positions 1¼" double-seated valve at 1000 p.s.i. pressure drop, with input signal ranges of 1-5, 4-20, or 10-50 ma. Completely self-contained. Easy, low-cost installation. Position repeatability within .002". Automatic locking with power failure simplifies start-up of process. Division I construction for hazardous service is standard. Other models available for heavier duty.



GPE Controls | A GENERAL PRECISION COMPANY

Write for descriptive literature

GPE Controls, Inc.

240 East Ontario Street • Chicago 11, Illinois

A Subsidiary of GENERAL PRECISION EQUIPMENT CORPORATION

CIRCLE 1 ON READER-SERVICE CARD

LEWIS SELECTOR SWITCHES

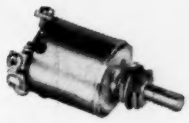
for RESISTANCE THERMOMETERS • for THERMOCOUPLE THERMOMETERS

THE 9S SERIES / *The Space Savers*

Small, sturdy, steel cased switches, 1¼ inches in diameter, 2$^{9}/_{32}$ inches total shaft length, one-hole mounting with ½ inch-32 NS-2A threaded bushing. Designed especially for connecting two or more resistance bulbs to one instrument.

Part No.	Description
9S5	Single pole, four positions (with knob)
9S5B	Single pole, four positions
9S5E	Single pole, five positions
9S10	Double pole, double throw

All make before break, the instrument connected is never subjected to an open circuit during the switching operation.



1¼ INCH SIZE

EACH SWITCH HAS "OFF" POSITION PLUS NUMBER OF POINTS LISTED.

Points	Size	Switch Part Numbers: Thermocouple Type	Switch Part Numbers: 3 Wire Resistance-Thermometer Type
2	2″	11S2	36SR2
3	2″	11S3	36SR3
4	2″	11S4	36SR4
5	3″	10S5	37SR5
6	3″	10S6	37SR6
8	3″	10S8	37SR8
9	3″	10S9	37SR9
10	3″	10S10	37SR10
12	3″	10S12	37SR12
16	3″	10S16	37SR16
18	3″	10S18	37SR18
20	3″	10S20	37SR20
24	4″	27S24B2	38SR24
28	4″	27S28B4	38SR28
40	4″	38S2C	

(No. 38S2C is made with soldering-lug terminals)

2 INCH SIZE

3 INCH SIZE

SPECIAL SWITCHES 37S6C2, Four "4-point and OFF" thermocouple switches combined in one 3″ case.

The 44S Series, 2$^{9}/_{32}$ inches in diameter, shaft 2¼ inches, approx. One-hole mounting with ½ inch-32 NS-2A threaded bushing.

Part No.	Description
44S4	Six pole, double throw
44S7B	Double pole, four position
44S7B2	Double pole, double throw

For use with resistance thermometer, contacts make before break.

DESIGNED FOR TEST WORK AS WELL AS FOR PERMANENT INSTALLATIONS. LEWIS SELECTOR SWITCHES ARE CONSTRUCTED WITH STURDY CONTACTS OF LOW RESISTANCE AND POSITIVE DETENT. THESE SWITCHES ARE SPLASHPROOF, DUSTPROOF AND ARE BUILT TO GIVE YEARS OF SERVICE.

4 INCH SIZE

THE LEWIS ENGINEERING CO.

Specialists in Electrical Temperature Measurements

NAUGATUCK, CONNECTICUT

CIRCLE 2 ON READER-SERVICE CARD

A SENSITIVE RESEARCH

TRIPLE PLAY!

1. AC-DC WIDE RANGE CALIBRATOR

SRIC's versatile AC/DC Volt-Amp-Milliammeter "Self Checking" Model Thach is now offered in combination with a general purpose power supply for use as a convenient, economically priced, wide range instrument calibrator. The Model Thach has 19 overlapping full scale ranges of current and voltage. Operation is almost always at or near full scale for maximum accuracy. The power supply (Model Thach-PS) is a regulated source with its controls interlocked with the Model Thach. Power to the Thach is automatically shut off when ranges are switched, reducing the danger of accidently overloading the calibrator and/or the instrument under test. Output covers the full range of the Thach for DC and 60 cps. 50-2500 cps. can be plugged in for operation over a broader frequency range. Resolution of the power supply controls is better than .05% for any current and voltage range.

Any Model Thach with range combs. 1x or 3x is available for operation with the power supply. In addition, existing instruments in the field can be modernized for this same purpose at a small surcharge.

2. AC-DC LABORATORY STANDARD

The Model Thach can be used independently as a true RMS measuring instrument powered by any appropriate source. It checks its own accuracy against an internal standard cell, and is furnished completely self contained with a high sensitivity galvanometer. General specifications are as follows: Accuracy ± .2% F.S. (.1% at self-check points). Ranges 10/20/50/100/200/500 ma; 1/2/5 amps; 1/2/5/10/20/50/100/200/500/1000 v. Frequency range DC and 7 cps. to 4 kc. Sensitivity 100 ohms volt. Thermocouple D'Arsonval type. 100 division 6.3" hand drawn mirrored scale. Temperature compensated from 20°C. — 30°C. 1000% manually operated overload protection system. Independent of influence of stray magnetic fields. Diamond Pivoted with sapphire shock mounted jewels. Furnished with 1 or 2 thermocouples. Available in two combinations: 1x is self checking at full scale only: 3x is self checking at 5 cardinal points including full scale. Size 16⅜" x 10½" x 8¾" deep. Weight approx. 21 lbs.

Model THACH AND THACH-PS

3. AC-DC GENERAL PURPOSE POWER SUPPLY

The Model Thach-PS, while designed primarily for operation with the Model Thach, can be used independently as a power source for any appropriate application. It only has to be disconnected from the Model Thach to become an excellent general purpose switch controlled laboratory supply.

SPECIFICATIONS:

OUTPUT: DC or AC (60 cps normal; 50-2500 cps depending on input) **Voltage:** Delivers 0-120% at full load and a max. of 0-175% at no load. 1/2/5 v. at 300 ma.; 10/20/50 v. at 100 ma.; 100/200/500/1000 v. at 25 ma. **Current:** 0-5 amps. at 15 watts max. on low power, or 75 watts max. on high power.

INPUT: 90-135 v., 60 cps single phase, or 115 v. 50-2500 cps from a regulated source.

WAVEFORM: 60 cps distortion 2.5% total harmonic content plus line distortion.

RIPPLE: Varies from .5% at full voltage and low currents to a maximum of 2.5% for currents of 1 ampere or less. At currents above 1 ampere, ripple can always be 3% or less if series resistance is sufficient in external circuit and will be no worse than 7% for any possible operation.

RESOLUTION: .05% or better by means of coarse, medium and fine controls.

SIZE: 12¾" x 17" x 9" deep.

WEIGHT: Approx. 59 lbs.

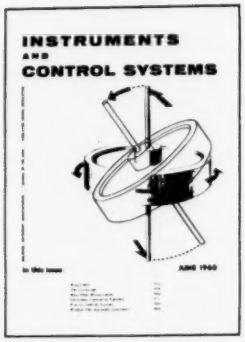
S Symbol of Quality

SENSITIVE RESEARCH INSTRUMENT CORPORATION

NEW ROCHELLE, N. Y.

CIRCLE 3 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS



GYROSCOPIC PRECESSION has many uses in instrumentation, including mass flow integration. Story on page 958.

VOLUME 33
NUMBER 6

JUNE
1960

EDITORIAL

WJCC-ISA-NTC 951
California had a lot of important meetings in May

Technical Communications 952

FEATURE ARTICLES

Ring Codes 954
ROBERT W. BROOKS—a means of dividing pulse frequency and performing synchronous logic

The Gyroscope 958
MILTON H. ARONSON—the gyroscope has two useful properties—inertia and precession. The latter has uses in instrumentation

The Hot-Wire Anemometer 962
O. C. WOLF—an instrument for measurement of rapidly fluctuating velocities and temperatures

Mass Flow Measurement (Journal of the S.C.M.A.) 966
ROBERT SIEV—axial-flow, radial-flow, gyroscopic, vortex velocity, and thermal devices are available to measure mass flow of liquids

Electronic Control Of Pipelines 972
P. H. DRINKER—how new electronic control instruments can handle seven unusual pipeline requirements

Transducer Evaluation 979
GEORGE VON VICK—defining the phenomena displayed by transducers

Process Control Systems 984
FRED D. MARTON—back-pressure control unit uses long-stroke rolling seal; alkalinity control of process water by conductivity; remote indication of level in deaeration feed tank

Welded Thermocouple Junctions 988
HENRY C. JORDAN—equal in importance to selection of wire is method of joining the wires

Resistance Elements For Missile Temperatures 992
H. N. NORTON—missileborne transducers have many environmental extremes

Pressure and Temperature Compensation of Flow Signal by Computer 994
BASIL MIKHALKIN—computer program for compensation

Testing Small Orifices 996
JAMES M. BENSON and CHARLES E. HAWK—a mass flowmeter can be used for check of orifice diameter of small nozzles

INSTRUMENTS AND CONTROL SYSTEMS

VOL. 33 NO. 6
JUNE, 1960

PRINT ORDER THIS MONTH: 38,500

Digital Flow Control **998**

HUGH O. JACOBSON—an oscillator controls flow rate.

Instruments Are Affected By Vibrational Environment **1001**

C. E. WHITE—use of precision instruments in new labs emphasizes effects of vibration on instrument operation.

The Dall Flow Tube **1006**

RODGER B. DOWDELL—unique flow tube combines high differential of an orifice with low loss of a Venturi.

NBS Flow Program **1011**

NBS has been conducting liquid-flow-rate standardization program to provide accurate basis for measurement of aircraft fuel system flow rates.

The Simulation Council Newsletter **1013**

Meeting on Process Controllers 1015
Meeting on Human Simulation 1021

OTHER REGULAR FEATURES

Letters to the Editor 902
News 914
People in the News 918
Briefs 922
Trends 925
Events 927
Panhandle Pete 943
Books 947
New Instruments 1024
New Literature 1062
Advertisers' Index 1066
Inquiry Card 1067
Product Index 1067

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By answering an obvious need for a completely new, up-to-date approach to counting and timing instrumentation, CMC has produced solid state instruments with greatly simplified circuitry, using logic "and" and "or" gates.

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Each 700 series instrument weighs only 27 pounds, measures 7 inches high, 17 inches wide, and 14 inches deep. Power consumption is a meager 46 watts, 1/10 the amount for vacuum tube models.

DO ALL THESE JOBS

Measure frequency from dc to 10 mc, time interval from 0.1 μsec, ratio 1 cps to 1 mc and unlimited multiple period selection. Frequency converters available for higher frequencies. The counter also generates time interval marker pulses from 1 μsec to 1 second. Data can be presented on standard decades or inline Nixie tubes. The 700 series will operate digital recording equipment, punches, inline readouts, and other data handling gear.

These Features, Too—Decade count-down time base—frequency divider circuits never need adjustment. Accuracy, ±1 count ±oscillator stability. Sensitivity, 0.25 v rms; input impedance, 25 k ohms/volt.

And The Price—Higher than vacuum tube models. But you can save the difference on down time in the first year. Model 727A Universal Counter-Timer, **$2,750**; Model 707A Frequency-Period Meter, **$2,575**; Model 757A Time Interval Meter, **$1,975.** Rack mount optional at no extra cost. All prices f.o.b. Sylmar, California.

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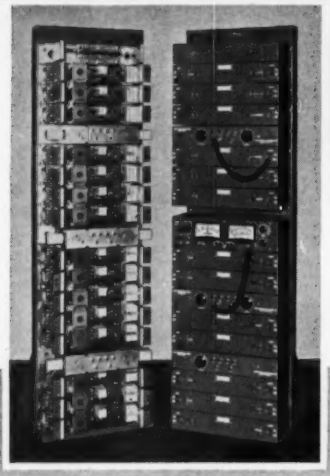
CIRCLE 4 ON READER-SERVICE CARD

REMOTE INSTRUMENTATION & CONTROL



Hi-Speed

DATA TRANSMISSION TERMINAL

Frequency Shift Terminal Equipment for Transmission of Data at Bit Rates to 7000 per second.

May be operated over open wire Telephone Circuits.

Designed for Direct Application to Microwave System Basebands without additional Carrier Channels.

RFL Model 1726

The Model 1726 Data Terminal was designed for applications involving the transmission of data at high speeds and can be used in either simplex, half-duplex or full-duplex data systems. Twenty-one individual channels, each capable of handling a bit rate of 2400 bits per second are placed in the frequency band of 20 to 110 kc. As an additional arrangement, five channels with a bit rate of 7000 bits per second may be placed between 51 and 105 kc.

The channel transmitter may be keyed by voltages, (10-volt min.) currents or dry contacts and develops an audio output which is continuously adjustable from −25 to +3 dbm. The receiver will operate from an input signal of +3 to −40 dbm and develops output voltage pulses as high as 25 volts for direct operation of end equipment.

The unit is designed for 19½" relay rack mounting and requires 3½" of rack space. The frequency determining components are of plug-in type thus keeping spare part requirements to a minimum as all other circuits are common to all channels. Jacks are included for DC loop and audio monitoring purposes. The equipment is available packaged as a single or dual transmitter or as a single receiver with a power supply included in each case.

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CANADA
Microwave Sys., Scarborough, Ont.
FOREIGN
Telesco International, New York

SEND FOR TECH. DATA — For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

CIRCLE 5 ON READER-SERVICE CARD

LETTERS TO THE EDITOR

Editor, I&CS:

We have been advised by friends in South America that they are interested in sending up one of their electrical engineers to the United States to complete his training in instruments including design, installation, and repair. As you have done considerable work in this field and are familiar with the courses of study available for this purpose, we are interested in receiving your suggestions and recommendations so that we may be able to assist our friends in selecting the training which would be most suitable for their purposes.

We understand that the Instrument Society of America is in Pittsburgh; can you advise us who we may contact in this organization?

D. Alterman
Bunge Corp.
New York 4, N. Y.

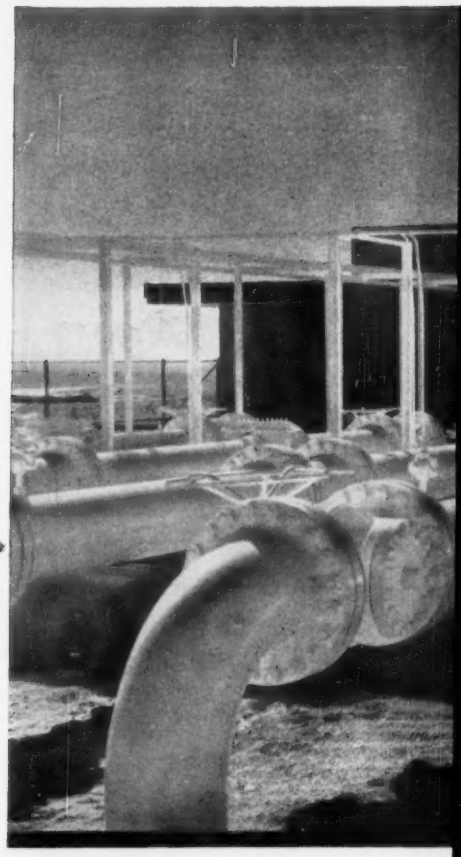
The August, 1959 issue (p. 1196) surveys the several courses in instrumentation given by the major instrument manufacturers and offered free of charge to users.

For college-level courses, we recommend (1) Case Institute of Technology, University Circle, Cleveland 6, Ohio, (2) Lehigh University, Bethlehem, Pa., (3) University of Michigan, College of Engineering, Ann Arbor, Mich., and (4) the Pennsylvania State University, University Park, Penna.

Other Institutions of higher learning conduct courses on special instrument subjects, such as Illinois Institute of Technology, Technology Center, Chicago 16, Ill.; Los Angeles Harbor Junior College, 1111 Figueroa St., Wilmington, Calif.; New York University; Massachusetts Institute of Technology, Cambridge 39, Mass.; Boston College, Chestnut Hill, Mass., etc.

On a technician's level, courses are offered by several area-type schools including Penn Technical Institute, 5440 Penn Ave., Pittsburgh 6, Pa. Public-school evening courses are underway in Pittsburgh (contact C. Hoffmaster, Pittsburgh Board of Public Education, Forbes & Bellefield, Pittsburgh, Pa.) In Philadelphia the Board of Public Education will hold evening courses starting next fall. (Address: Murrell Dobbins Vocational-Technical School, 22nd St., and Lehigh Ave., Philadelphia 32, Pa.)

The Instrument Society of America (ISA) has headquarters at 313 Sixth Ave., Pittsburgh 22, Pa.

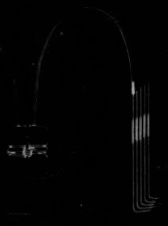


ORIFICE METERS

American-Westcott Dri-flo and mercury manometers in recording, indicating and integrating models—to 5000 psi working pressure.

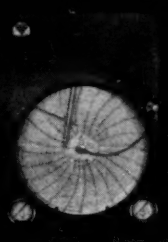
GASCLOK

Gas or air operated instrument power drive and timing unit for remote installations.



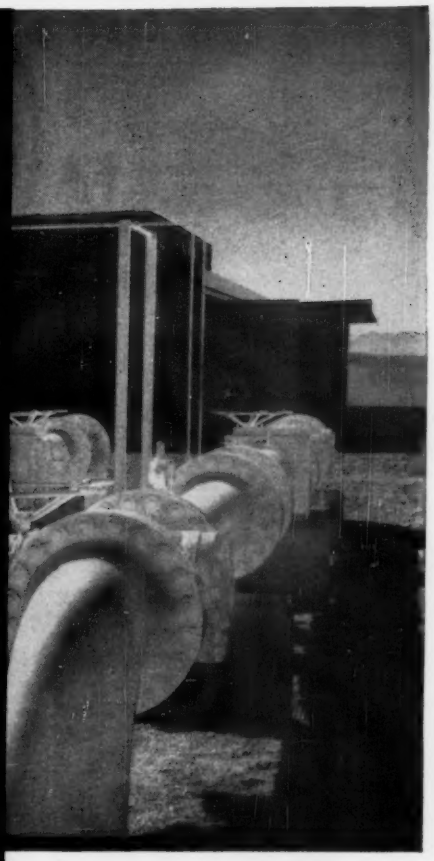
CANNON PENS

Controlled-flow capillary meter pens record up to a full year without refilling—eliminate chart smearing and blurring.



CONTROLLERS

Series A-88 Controllers, Transmitters & Receivers for control of continuous process variables. Telemetering Systems designed to meet your requirements.



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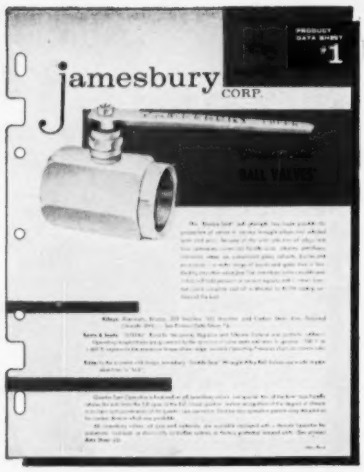
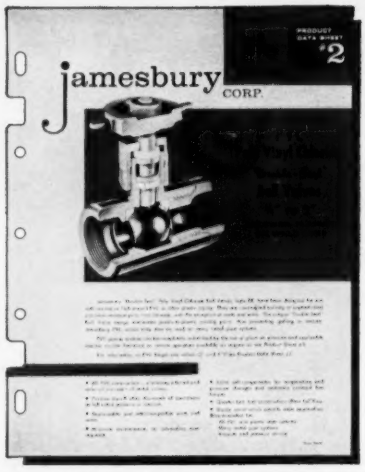
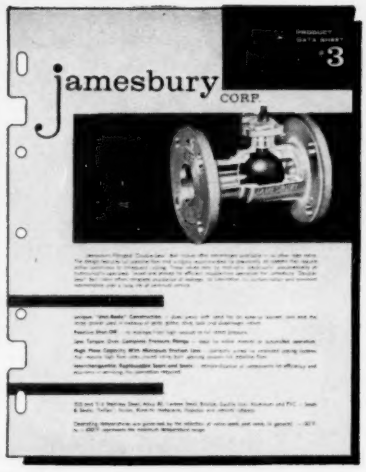
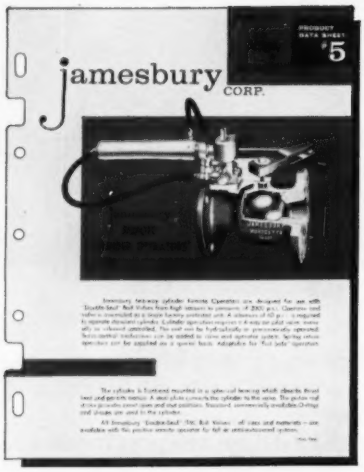
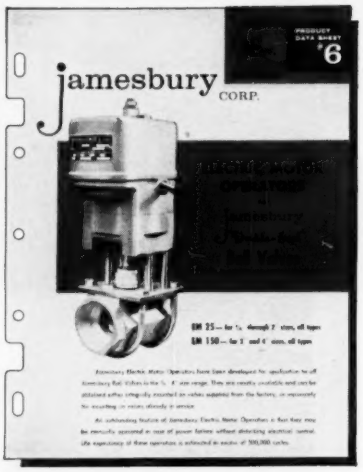


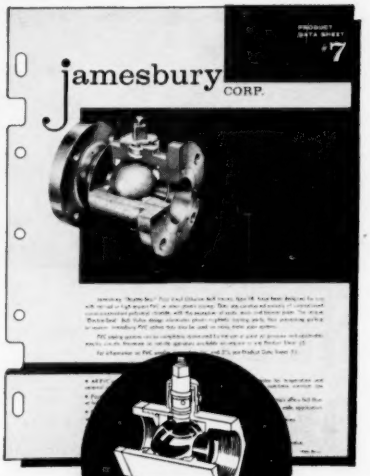


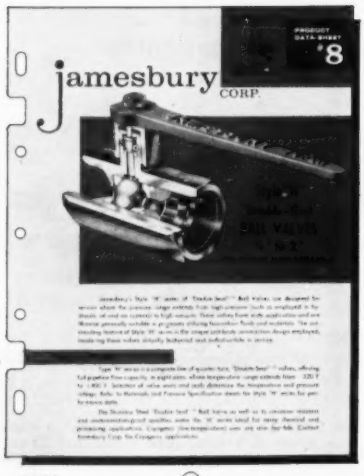


FACTUAL DATA









on jamesbury BALL VALVES

AS VERSATILE AS INDUSTRY ITSELF

Get the full story on Jamesbury Corp.'s complete line of "Double-Seal" Ball Valves and accessories. Learn why the Jamesbury "Double-Seal" Ball Valve has been labeled "as versatile as industry itself". Get all the facts on materials, sizes, etc. They are yours for the asking: the facts about Jamesbury Corp. — the nation's foremost exclusive manufacturer of Ball Valves.

JAMESBURY CORP.
NEW STREET, DEPT. PDS, WORCESTER, MASS.
Please send me the Data Sheets checked below.

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Name..... Title.....

Company.....

Address..... City..... State.....

126-0

JAMESBURY BALL VALVES
HELPING BUILD OUR NUCLEAR NAVY

JAMESBURY CORP., 78 NEW STREET, WORCESTER, MASS.

Distributors in Principal Cities

CIRCLE 7 ON READER-SERVICE CARD

Editor, I&CS:

A recent letter in your "letters to the editor" column (April, 1960) said, "if we had to define this period we would certainly have to call it the 'Era of Certification and Standardization'."

This idea is well taken. In 1883, Lord Kelvin made his oft-quoted statement which so well expressed the state of the art of science in the 19th century:

" . . when you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind, it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the state of science, whatever the matter may be."

If Lord Kelvin were alive today, perhaps he would express the state of the art in instrumentation by this simple paraphrase of his original statement:

"when you can verify your measurement with calibration based on a known frame of reference, you can then and only then express those numbers derived from your measurement with knowledge. When you cannot verify your measurement, your measurement is of meager and unsatisfactory kind; it may be the beginning of measurement, but you have scarcely, in your technique, advanced to the state of accurate measurement, whatever the measurement may be."

Russell G. Smith
Reference Standards Laboratory
Long Beach Naval Shipyard
Long Beach, California

Editor, I&CS:

I have been getting *INSTRUMENTS AND CONTROL SYSTEMS* for about 6 months now, and like it immensely . . . Do you have a booklet on electronic and digital terms?

J. E. Kreiss,
Sacramento, California

Editor, I&CS:

I would like a copy of the article "Report of High School Course in Modern Engineering Physics" from your February 1959 issue.

J. L. Carlton
Research Engineer
Edward Valves, Inc.
East Chicago, Indiana

hays

RAMBLINGS ON INSTRUMENTATION

Computers and all that jazz

Hello, I'm Shelley Sprague and my daddy said I better fill this space because he's afraid he's losing his grip. He *has* been acting pretty funny. Sort of like you get with a Frankie Avalon record. Not that a square like daddy would know Frankie Avalon from third base. A Lawrence Welk man if you know what I mean.

Anyway Daddy came home one night and said with a big grin, "Guess what! I discovered today that Hays is in the *computer* business!" Big deal. Like we should do handstands or something.

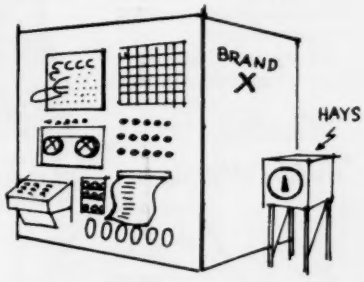
Dennis, my impossible brother, didn't even look up from his issue of *Mad*. He just said "Tslltph." It's something he says deliberately to needle people.

So the old boy polishes his hornrims very slowly which means he's about to flip his lid but not for a few minutes yet. "I refer, Dennis, to the fact that the Hays Universal Recorder actually performs many of the functions commonly associated with computers. Our engineers have made a detailed comparison that reveals we haven't been giving ourselves enough credit for the computer technology we're actually applying at Hays and this has given our whole organization a tremendous lift and is a source of considerable personal pride to myself and, I think, warrants a bit more of a reaction than 'Tslltph'," etc., etc., etc. . . .

So Dennis looks up from *Mad* with that Look. Like when you open the freezer and see a mackerel staring at you. "Comparing the Hays Universal Recorder with a truly sophisticated computer is like comparing the Queen Mary with a canoe," said Dennis in that flat voice he has. And he drew Daddy a picture only he shouldn't have drawn it on the wallpaper.

Now Daddy is doing the glasses-polishing bit again. *Murder!* "The Hays Universal Recorder can add and subtract . . . and we've set up instruments to totalize algebraically . . . and Hays compensated flow meters utilize multiplying circuits. For example our Hays Universal recorder will multiply Delta T and flow to record the BTU's absorbed or released in a process as well as any of those overgrown pinball machines." Daddy's voice is getting a little shrill now.

And so Dennis wants to know how many complete programs the Hays Universal Recorder is capable of and Daddy says huh? and Dennis gives him that Look—but sorrowful.



And then Dennis says that computer technology involves the principle of binary selection, as any idiot knows, and is binary circuitry used in the Universal Recorder? But Daddy just said huh? again and so Dennis drew a diagram explaining the principles of binary selection. He was just trying to be helpful of course but Daddy didn't appreciate it. Especially since Dennis drew on the wallpaper again. Honest, it was fire in the paint locker there for a few minutes. Like *wild!*

Finally Daddy didn't say anything anymore. He just sat there. I mean it was sort of creepy. Just sitting there with this glaze on his eyeballs.

Even Dennis looked a little scared and man, that's Endsville! So he tried to cheer Daddy up. "Cheer up, Daddy-O" he says, patting him on the head. "Actually the Hays Universal Recorder *does* perform computer functions, accurately and at low cost, adding, subtracting and multiplying with analogs representing process variables. You bring home any bubble gum?"

And then Mommy brought Daddy a martini and Daddy began to look almost normal again, whatever that is, and didn't even say anything when I put on Frankie Avalon. But he still has that glaze on his eyeballs and he hasn't discussed business with Dennis ever since.

Shelley Sprague

(President's Daughter)

P.S. And I'm supposed to put in that Hays has a booklet about this computer jazz they'll mail you only you have to tell them where you live.

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

CIRCLE 8 ON READER-SERVICE CARD

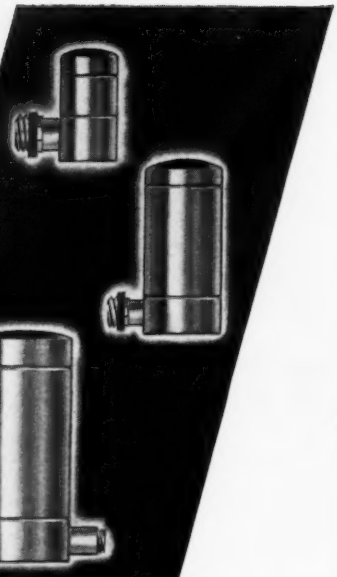
SPECIFY

MASSA TRANSDUCERS

FOR **RELIABILITY**
STABILITY
ACCURACY

Ammonium Di-hydrogen Phosphate (ADP) crystal provides the best known piezoelectric transducer element to achieve RELIABILITY, STABILITY and ACCURACY with *Time* and *Temperature* and is therefore used exclusively in all Massa instruments for measuring acceleration, sound pressure and underwater (hydrophones) sound pressures.

The Accelerometers have Frequency Ranges up to 90,000 cps and Dynamic Ranges from .001 to 2000 g's.



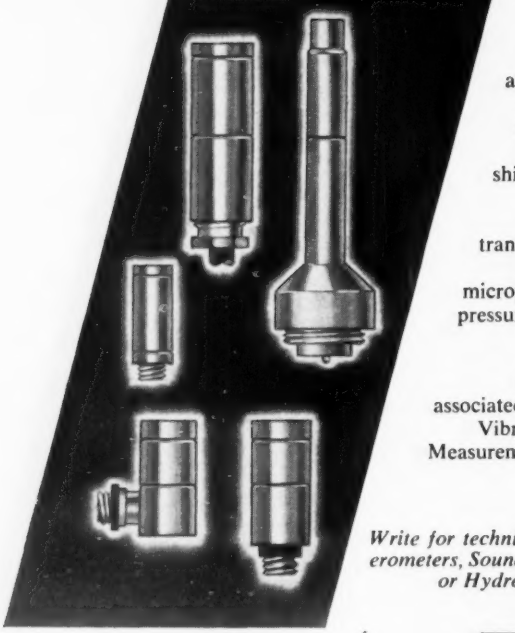
Vibration Measurement

ACCELEROMETERS

ADP

MICROPHONES

Sound Pressure Microphones



The Massa microphones are stiffness controlled over the specified frequency ranges of 10 cps to 90,000 cps with negligible phase shift errors, making the units ideal for the accurate reproduction of acoustic transients and linear response. The dynamic range of the microphones are linear to sound pressures in excess of 200 db. (re .0002 microbars).

Massa also manufactures associated accessories for complete Vibration and Sound Pressure Measurement Systems, available for immediate delivery.

Write for technical data sheets on Accelerometers, Sound Pressure Measurements, or Hydrophone Standards.

Other MASSA Products

RECORDING SYSTEMS

HYDROPHONES • SONAR TRANSDUCERS

MASSA
A DIVISION OF
COHU
ELECTRONICS, INC.

12 FOTTLER ROAD

HINGHAM, MASSACHUSETTS

CIRCLE 9 ON READER-SERVICE CARD

Editor, I&CS:

I have been a subscriber to your magazine *Instruments and Control Systems* since about 1942. I have had my subscription continuously. Every now and then it looks as though I ought to stop my subscription and start it over again in order to take advantage of the wonderful free offers you make trying to entice new subscribers.

Keep up the good work on your magazine. I find it very useful. In particular, I find your *Buyers' Guide* of considerable use. Several of the men I work with, as well as myself, use it frequently.

Best regards to a successful magazine.

A. Pete Ianuzzi
Bulova Research & Development Laboratories, Inc.
Woodside, N. Y.

The "special offers" we make to entice new subscribers comprise nothing more than reprints from articles that have already appeared in *INSTRUMENTS AND CONTROL SYSTEMS*. Thus you faithful old readers are not actually being shortchanged at all; you already have received all this material in your past issues.

Reader Inquiries

Application Service

Inertial-navigation engineer is seeking service whereby a list of instruments, possibly usable in a particular application could be obtained. A-629

Magnetic Level-Indicator

Instrument engineer in refinery seeks magnetic-type level indicator for hydrofluoric acid alkylation unit using a non-magnetic outer tube with a permanent magnet built into the float to carry an iron ring up and down. Monel is preferred. A-630

Colorimetric CO Analyzer

U.S. representative of French automobile manufacturer seeks "colorimetric indicating tubes for detection of semi quantitative gas analysis, in particular suitable for detecting carbon monoxide." A-631

Product Identification

Instrument Rep wishes to identify: Heuwing Simple Drum-Kymograph and Starling Breathpump. A-632

IMPERIAL
Engineering and Data File

PUSH...IT CONNECTS! *CLICK*...IT DISCONNECTS!

Making instrumentation connections with this new, polished-chrome Kwik-Connect Coupler is simple and fast. No pushing and fumbling with special rings or clamps. No complicated mechanisms. It's a snap!

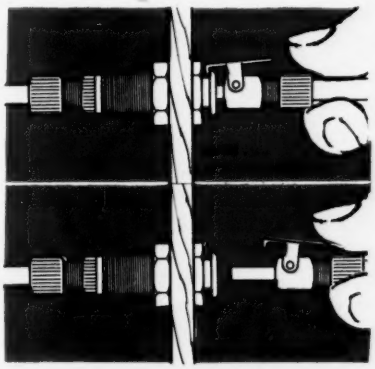
Just plug the parts together with a slight hand pressure. A unique cam action automatically moves the clip and locks the coupling in position. Inside, the flow is unrestricted through both the tube and coupling.

To uncouple, you simply press the spring-loaded clip. This disconnects the coupling and instantly seals off the flow. The patented shut-off feature is available in either the body end or the male connector end.

Other patented design features and the use of an "O" ring seal make Imperial's new Kwik-Connect Coupler a completely dependable connection far beyond the burst strength of polyethylene tubing.

LESS BULK, LESS WEIGHT

Only two moving parts — far simpler in design than ordinary quick couplers.



PROBLEM SOLVER

Kwik-Connect makes systems checking faster, easier. Ideal for pull-out consoles, test stands, panel boards, manifolding — eliminates the need for multiple gauges. Mounts on panels up to 1" thick.

Less bulky, lighter in weight. The ⅜" O.D. coupling weighs less than 3½ ounces; the ¼" O.D. coupling, less than 2 ounces. More dependable, too, because of a positive safety lock. It's the only quick-connect coupling that provides visual proof of a positive connection.

Kwik-Connect Couplers are available two ways: tube-to-tube or tube-to-pipe thread. Tubing connections are Imperial Poly-Flo fittings which need only be finger-tightened, providing easier assembly, faster installation of polyethylene or other plastic tubing. Universal sleeve and nut available for nylon and metal tubing. Couplers fit bulkheads up to 1" thick.

WRITE TODAY for Bulletin 3119 giving complete information.

THE IMPERIAL BRASS MANUFACTURING CO.
Dept. ICS-60, 6300 West Howard Street
Chicago 48, Illinois

CIRCLE 10 ON READER-SERVICE CARD

NEW low cost multi-purpose electronic counter

Model 720 events-per-unit-time counter is specially designed for industrial and laboratory uses where unusual flexibility is required. The unique modular construction permits the measurement of virtually any physical variable, such as rate of flow, RPM, frequency or time interval. NIXIE in-line readout is easy to read and reduces operator fatigue and the chance for error. Simplified construction permits operation by relatively unskilled personnel. Low Cost starts at $475 for the 3-decade model. Send for complete technical literature.

DECADES:	3, 4, 5 or 6
FREQUENCY RANGE:	0 to 120,000 pulses/sec.
SENSITIVITY:	50 Millivolts RMS
ACCURACY:	± one count ± time base error
DISPLAY TIME:	0.2 to 6 sec. or infinite
SIZE:	19″ x 5¼″ x 12″
WEIGHT:	25 lbs.

ERIE-PACIFIC manufactures a complete line of digital counting and timing instruments and systems for military or commercial use.

ERIE INSTRUMATION

ERIE PACIFIC DIVISION
ERIE RESISTOR CORPORATION
12932 S. Weber Way, Hawthorne, California
Phone: ORegon 8-5418

CIRCLE 11 ON READER-SERVICE CARD

Non-destructive Tester

Instrument engineer of design company seeks eddy-current non-destruc-

tive tester for detection of surface and subsurface flaws in ferrous tubing, indicating types and magnitude of flaws, penetrating depths, sensitivity, resolution, as well as automation mechanism for feeding, sorting, recording, and marking. Would prefer initially renting such instrument. Tube sample is illustrated. A-633

Correspondence Course

Engineer seeks correspondence course in digital and analog computers. A-634

BTU Recorder

Power-plant sales engineers seek BTU recorder for use in the water circulation system of a heat pump. Pipe size: 6″; range: 50 to 190°. A-635

Torque Measurement

Requisition engineer of large electronic concern seeks measuring instrument which indicates in in-lb (or hp) torque required to drive miniature gear train or flexible belt system (from input shaft) possibly with variable-speed drive. A-636

Water in Lime

Superintendent of lime-manufacturing plant seeks instrument measuring water content in lime hydrator during hydration process. A-637

Wind Tunnel Balance

Research assistant of university engineering school seeks manufacturers of strain gage wind tunnel balances. A-638

Ore Bin Channeling Detector

Application engineer of large electric concern seeks information on above instrument. A-639

Percentage Input Controller

Manager of electronics company seeks percentage input controllers for electric heating elements. A-640

Millivoltmeter

Purchasing agent for manufacturer of carbon- and powdered-metal products seeks millivoltmeter to check automotive electrical circuits similar to the GE crest meter. Range: 0-30 mv. A-641

0110 1001 1001 1000

RECOMP

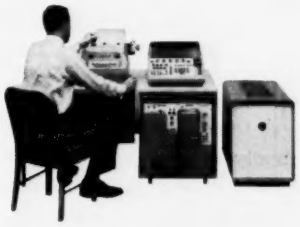
THINKS IN "BITS" BUT TALKS YOUR LANGUAGE

The binary combinations of ones and zeros stored in computers are called "bits"... and there are 160,000 of them stored in RECOMP.

RECOMP's exclusive readout panel converts these "bits" into arabic numerals... providing fast, easy readout of any word or number in the magnetic disk memory. RECOMP *communicates* in your language. Under computer control or at the push of a button, the unique readout displays in a choice of three formats: decimal, octal, or command.

The all-transistorized, general purpose RECOMP has built-in floating point and square root arithmetic... high-speed photoelectric tape reader (400 characters per second)... 4,096-word memory, including 16 words placed in high-speed loops, and a storage capacity of over 8,000 instructions.

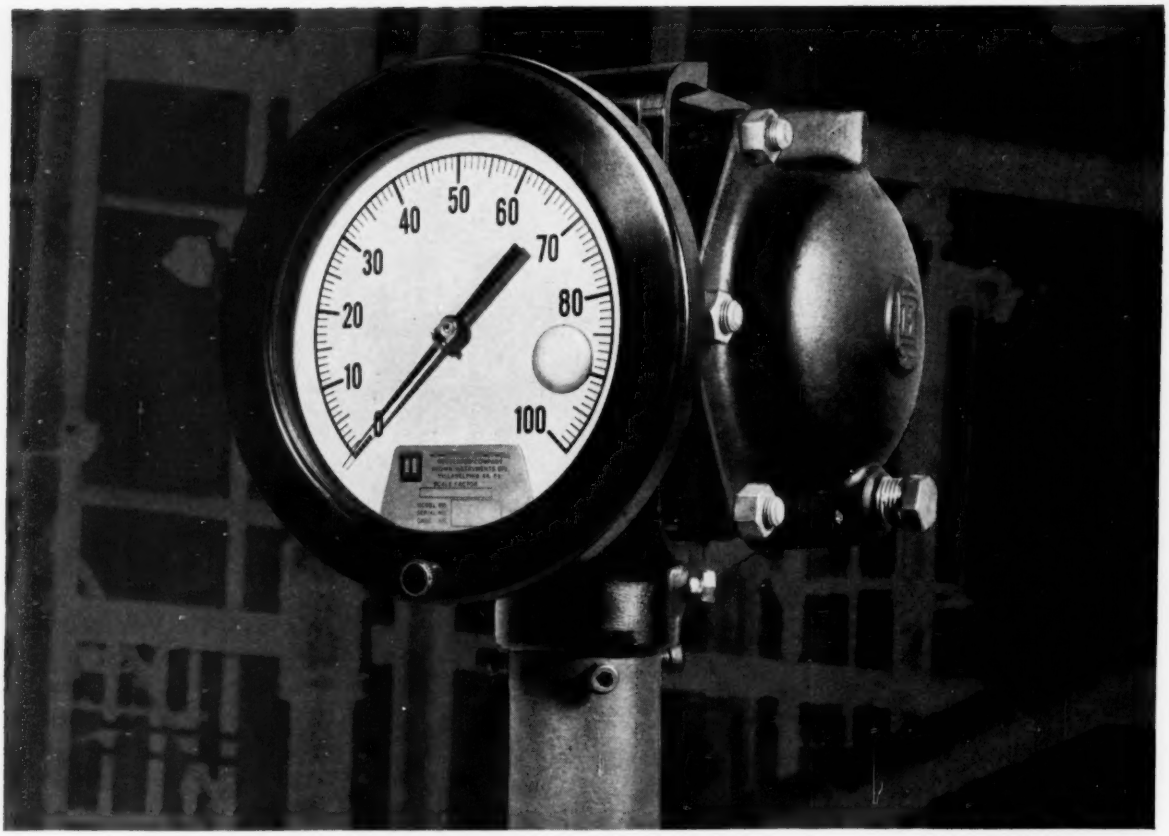
RECOMP provides fast and accurate answers to problems of engineering, science and industry. It's available now for sale or lease... *and there's no extra equipment to buy or cost of installation.* For information on how RECOMP can solve your special problems, please write Autonetics Industrial Products, Dept. **606,** 3584 Wilshire Blvd., Los Angeles 5, California.



Digital computers by Autonetics

INDUSTRIAL PRODUCTS

A DIVISION OF NORTH AMERICAN AVIATION, INC. Other offices: Chicago, New York, Washington, D.C.



New indicating bellows meter is accurate, rugged and safe in any atmosphere

Use this new bellows meter for any flow or liquid level application where you want local indication, but don't need recording or transmission. It combines the advantages of the mercuryless bellows meter body with the convenience of an easy-to-read 6-inch dial indicator.

Make pressure connections from either the top or bottom of the meter body, depending on whether you want the meter to be self-venting, draining or purging. And forget corrosion worries; all parts of the bellows exposed to process fluids are of seamless stainless steel construction.

This rugged meter will perform accurately in the toughest service. Two meter bodies are available with pressure ratings of 1000 and 2500 psi, tested at 1500 and 4000 psi respectively. And you can use the meter in hazardous atmospheres because it is self-powered . . . at any ambient temperature between −40° and +250°F. In the indicating movement, a stainless steel pointer pinion and a nylon-faced gear sector assure long life and sustained calibration accuracy of ±1% full scale (ranges of 0-50 inches of water and above) and ±1¼% full scale (ranges below 0-50 inches of water).

This new bellows meter has many other features . . . ease of calibration, simple range change, automatic ambient temperature and static pressure compensation, to name a few. Your nearby Honeywell field engineer can give you complete details. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

75th YEAR
PIONEERING THE FUTURE

Honeywell
First in Control
SINCE 1885

CIRCLE 13 ON READER-SERVICE CARD

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

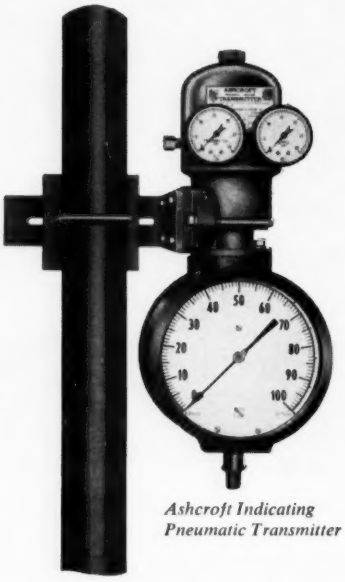
®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

signal action

ASHCROFT PNEUMATIC TRANSMITTERS give you a true primary and transmitted signal for indication or control



Ashcroft Indicating Pneumatic Transmitter

Now—detect with precision accuracy the slightest change in primary pressure or temperature. Transmit this signal quickly to your indicators or controllers. Ashcroft Pneumatic Transmitters achieve these results for you at the lowest initial and operating costs.

Full-range, solid-front indicating and totally accessible nonindicating transmitters eliminate the need for costly high pressure lines, yet permit complete monitoring of process conditions in remote areas.

Narrow-span Ashcroft Transmitters are expressly designed with highest sensitivity and repeatability for the most accurate primary signal feed to controllers. You get better control and purer, lower-cost final products.

Only in Ashcroft Pneumatic Transmitters can you get the wide choice of Ashcroft Duragauge Bourdon tubes or American mercury or gas-actuated systems for sensing pressure or temperature conditions. You also get a time-proven, obstruction-proof, force-balance, nonbleed relay for economical, maintenance-free 3-15 psi or 3-27 psi signal transmission.

Write for factful Bulletins 360 and 361 or ask your nearby Ashcroft Distributor to help you select the right transmitters and receiver gauges for your specific requirements.

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

ASHCROFT PNEUMATIC TRANSMITTERS

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 57 ON READER-SERVICE CARD

TO THE ENGINEER

who can't tolerate a lapse of memory

If you're working on a think machine that can't afford to break its train of thought, consider AE's pint-size, fast-stepping OCS switcher. Unlike electron tubes and relays, this sophisticated device won't lose stored memory in the event of power failure or circuit interruption.

Besides, it can do the work normally assigned to whole banks of relays.

The AE Series OCS will follow or initiate a prescribed series of events or cycles at 30 steps per second impulse-controlled, or 65 steps per second self-interrupted. Any programming sequence can be set up on one to six cams with as many as 36 on-and-off steps per cam. And each cam will actuate as many as six contact springs.

In any event, if your designs involve relays or stepping switches, AE circuit engineers may be able to save you a pretty penny. Or, if you'd like to leave the switching to us, we're equipped to supply prewired and assembled, custom-built control units, *or* help you develop complete control systems.

To explore the matter, just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1698-H: *Rotary Stepping Switches;* Circular 1702-E: *Relays for Industry;* and our new 32-page booklet on *Basic Circuits.*

AE CAN DO

AUTOMATIC ELECTRIC GENERAL SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

CIRCLE 33 ON READER-SERVICE CARD

ICS NEWS

Computer to Help Study the Human Mind

PASADENA, CALIF.—California Institute of Technology will take a big step toward unlocking the secrets of creative thinking with the dedication of a new electronic computer system today. Raw data derived from basic research on the human nervous system will be fed

into a Burroughs 220 electronic computer, programmed to prepare a mathematical model of the human mind. By the rapid simulation of brain functions on the 220, a nearly infinite number of hypotheses about human thinking can be tested.

The artificial intelligence program got underway in February of this year when Caltech sponsored a four-day symposium to evaluate current knowledge on the nervous system. Thirty-five leading biologists, electronics and communications-theory experts from the United States and Europe met to discuss theories and recommend areas of future research.

The heart of Caltech's computer center is the Burroughs 220, a gift from the Burroughs Corporation.

ELION INSTRUMENTS, a new firm, founded by former RCA men, is marketing an Electron Spin Resonance Spectrograph which may be useful in computer control of process systems. By shooting r-f energy into electrons spinning in the atom, a precise quantitative analysis of the molecular and bonding structures of solids, liquids, and gases can be obtained with oscilloscopic, oscillographic or voltage read-out into a computer system.

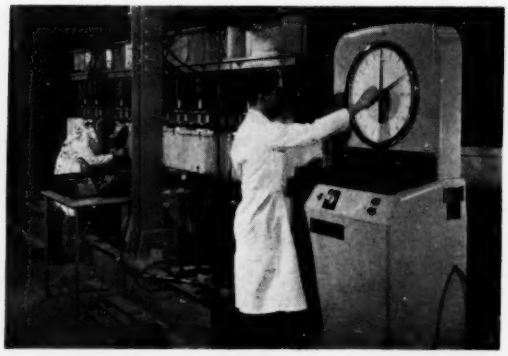
FOR MORE INFORMATION CIRCLE 160 ON READER-SERVICE CARD

M-H's BROWN INSTRUMENTS DIV., in collaboration with Wilmot Engineering and Industrial Nucleonics, has developed a closed-loop control system, which was installed at Underkoffler Coal Service Co., Lykens, Penna., that holds the specific gravity of the separatory medium, a mixture of water and magnetite at 1.70 $\pm$0.00 at the widest spread. Recovery of low-ash coal and preparation of coal that is uniform in ash content have yielded substantial savings.

FOR MORE INFORMATION CIRCLE 161 ON READER-SERVICE CARD

Concrete Beam Tests

EAST MOLINE, ILL.—A Riehle Electro-Balanced Indicating Unit, Model F-400, in use by the Department of Theoretical and Applied Mechanics, College of Engineering, at the University of Illinois is applied to a static test



structure for concrete beams. Equipment was furnished by Riehle Testing Machines Div. of American Machine and Metals, Inc., East Moline, Illinois.

Technicians for Hire From General Electric

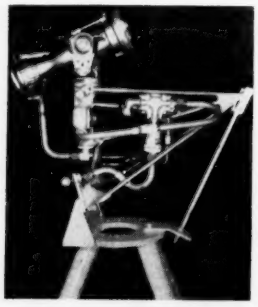
SCHENECTADY, N. Y.—A new service to industry has been announced by General Electric Co. It involves the hiring of skilled technicians, with the finest laboratory-type instruments, to measure and record virtually any quantity or combination of quantities. The service augments the company's instrument rental program inaugurated last year, and is likewise administered through the company's cross-country network of Service Shops.

Customers will be charged on a per diem basis without investment in the costly instrumentation needed, and with assurance of skilled, highly trained operators.

FOR MORE INFORMATION CIRCLE 162 ON READER-SERVICE CARD

BROWN INSTRUMENTS DIV. of Minneapolis-Honeywell has been admitted to the Century Club of SAMA. In the picture *Dr. George A. Downsbrough* (left), SAMA president, presents certificate for a century of service to Brown's Vice President *Henry F. Dever* in a climax of the association's recent annual meeting.

Dr. Downsbrough presents H. F. Dever with certificate.



HYDROMATICS Flo-Ball dual propellant valves, through which precise proportions of liquid hydrogen and kerosene-type fuel are fed into the combustion chambers of the two small vernier engines of the "Atlas" intercontinental ballistics missile, have proved to be of vital importance for the accuracy of the missile.

FOR MORE INFORMATION CIRCLE 163 ON READER-SERVICE CARD

THOR
MACE
TITAN
HAWK
ATLAS
SNARK
NIKE B
BOMARC
NIKE ZEUS
SPARROW I
SPARROW II
SPARROW III
NIKE HERCULES
SIDEWINDER
REGULUS II
VANGUARD
REDSTONE
JUPITER C
PERSHING
BULL PUP
MERCURY
POLARIS
CORVUS
FALCON

N/D Designs Assembly Savings Into Critical Miniature/Instrument Ball Bearings!

Helping customers *simplify* instrument assembly is a specialty of the N/D engineering group. How? Through *creative* Miniature/Instrument ball bearing application and design. Often, a new ball bearing design will produce assembly savings in excess of its additional costs. Integral ball bearings, too, very often cut down difficult and costly hand assembly of shaft and parts.

A timely example of N/D customer assembly savings can be seen in Nike Ajax and Hercules missile ground support. Here, *special* N/D Instrument ball bearings are now used in precision potentiometers. New Departure engineers recommended eliminating two *single row* instrument bearings, mounted in duplex and requiring precision spacer and separate guide roller. They replaced this assembly with a *special* N/D *double row* high precision instrument ball bearing with integral outer race guide roller . . . and shaft mounted with a nut. This *one* recommendation produced cost savings of over 400%! In turn, the customer was able to reduce the potentiometer selling price to the government. What's more, the New Departure Instrument Ball Bearings improved potentiometer reliability!

You can look to minimum assembly costs and unsurpassed *reliability*. Include an N/D Miniature/Instrument Bearing Specialist in your early design level discussions. For immediate information or assistance, call or write Department L.S., New Departure Division, General Motors Corporation, Bristol, Connecticut.

NEW DEPARTURE

MINIATURE & INSTRUMENT BALL BEARINGS

proved reliability you can build around

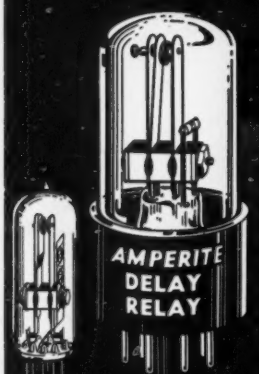
CIRCLE 16 ON READER-SERVICE CARD

AMPERITE PREFERRED

by design engineers—because they're
MOST COMPACT • MOST ECONOMICAL
SIMPLEST • HERMETICALLY SEALED

Thermostatic DELAY RELAYS

2 to 180 Seconds



Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.

Hermetically sealed. Not affected by altitude, moisture, or climate changes.

SPST only—normally open or closed.

Compensated for ambient temperature changes from —55° to +70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are **rugged, explosion-proof, long-lived,** and—**inexpensive!**

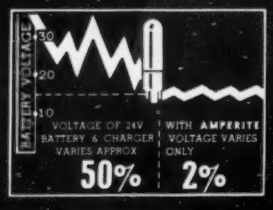
Also—**Amperite Differential Relays:** Used for automatic overload, under-voltage or under-current protection.

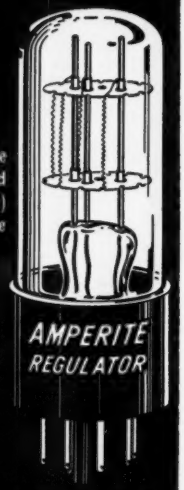
TYPES: Standard Radio Octal, and 9-Pin Miniature . . . **List Price, $4.00.** Standard Delays

PROBLEM? Send for Bulletin No. TR-81

BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit **automatically regulated** at a definite value (for example, 0.5 amp.) . . . For currents of 60 ma. to 5 amps. Operate on A.C., D.C., or Pulsating Current.





Hermetically sealed, they are not affected by changes in altitude, ambient temperature (—55° to +90° C.), or humidity . . . Rugged, light, compact, most inexpensive . . . . . **List Price, $3.00.**

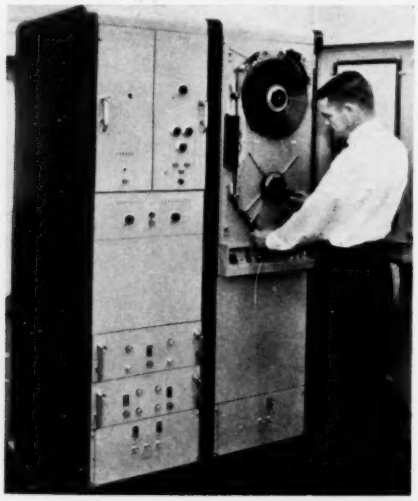
Write for 4-page Technical Bulletin No. AB-51

AMPERITE CO. Inc., 561 Broadway, New York 12, N. Y.
Telephone: CAnal 6-1446
In Canada: Atlas Radio Corp., Ltd., 50 Wingold Ave., Toronto 10

CIRCLE 17 ON READER-SERVICE CARD

High-Density Digital Recorder/Reproducer

PASADENA, CALIF.—A high-density digital magnetic tape recorder/reproducer Type 5-753 has been delivered to the Naval Ordnance Laboratory, Corona, Calif.



Recording and reproducing at packing densitities up to 2000 words/in on up to 16 tracks, is possible with the new instrument. Tape speeds of 60, 30, 15, and 7.5″/sec are selectable. A unique flangeless reeling system allows 8400 feet of 1″ wide tape to be wound into a 14″-dia reel. The system was developed by the Datalab Division of Consolidated Electrodynamics Corp., a Bell & Howell Subsidiary, 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 164 ON READER-SERVICE CARD

BENDIX G-20 high-speed data processing system will be installed in Carnegie Institute of Technology's computation center sometime next fall. Remotely controlling from different buildings on the campus, the various research centers can supply data to the computer and evaluate results from operating positions outside the computation center.

CIRCLE 165 ON READER-SERVICE CARD

CASE INSTITUTE OF TECHNOLOGY offers eight summer programs, including a summer study course in process control theory, under the direction of Dr. Donald P. Eckman, (July 11-20) professor of mechanical engineering and director of the Case Systems Research Center.

PHILADELPHIA'S BOARD OF PUBLIC EDUCATION has established a new course in instrumentation which will be opened in September for boys and girls who will be in the 12th grade next term, for those who will graduate in June, and for adults who are employed in the field of making use of instruments for measurement and process control.

A NATIONAL SYMPOSIUM on "Temperature—Its Measurement and control in Science and Industry" will be held in Columbus, Ohio, March 27-31, 1961 jointly sponsored by the American Institute of Physics, the ISA and the National Bureau of Standards. Those interested in contributing to the program should contact Dr. C. M. Herzfeld of the National Bureau of Standards, Washington 25, D. C., as soon as possible.

This "jeweled" escapement brings you fine watch quality in chart drives

See how easy it is to convert to seven different rotation rates

The main arbor on the basic chart drive has a rotation rate of seven days. Economical snap on turrets convert this rate to 8 day, 15 day, 16 day, 24 day, 30 day, 31 day and 24 hour rotation. No tools are required and you can even change chart rotation without removing the drive from the instrument.

Now, for the first time you get the extra value of a jeweled movement. This superior construction makes Rockwell chart drives more accurate and sensitive than ordinary chart drives. It requires less power to drive and is extremely durable since there are seven hard jeweled surfaces to overcome friction and wear.

You can use these jeweled movement chart drives *with profit* to power all your recording instruments. They will adapt into practically any instrument case. Speed changing turrets (see left) permit varying rotation rates at will. Write for bulletin. Rockwell Manufacturing Company, Dept. 58-F, Pittsburgh 8, Pa. In Canada, Rockwell Manufacturing Company of Canada, Ltd., P.O. Box 420, Guelph, Ontario.

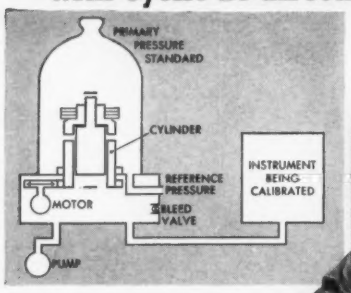
JEWELED CHART DRIVES

another fine product by

ROCKWELL

CIRCLE 18 ON READER-SERVICE CARD

NEW! PRIMARY PRESSURE STANDARD with Cyclic Bi-directional Rotation



Now you can calibrate any pressure measuring instrument from 0.2 psi absolute to 500.0 psi gauge with an accuracy of 0.015% of reading!

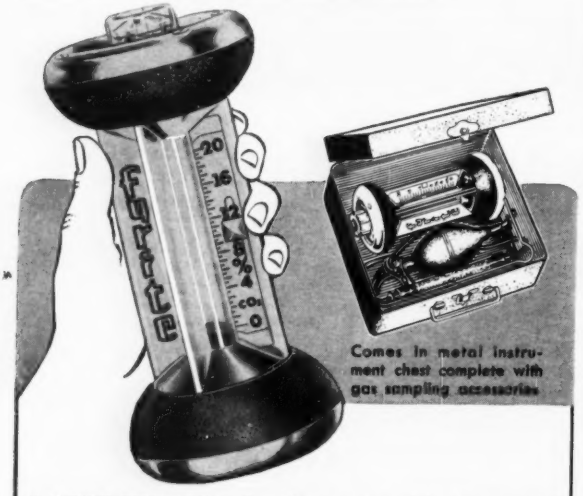
- Exclusive cyclic bi-directional rotation of cylinder minimizes lift error
- Four pressure ranges
- Use any reference pressure from zero to one atmosphere absolute
- Self-contained pressure source provides pressure up to 15 psi

Write for Technical Bulletin on Primary Pressure Standard.

DYNAMETRICS CORPORATION

Northwest Industrial Park, Dept. 18, Burlington, Mass.

CIRCLE 22 ON READER-SERVICE CARD



ACCURATE CO_2 Analysis in 40 Seconds!

Other outstanding features of the FYRITE CO_2 Indicator are its durable, fool-proof construction and unmatched convenience of operation. It requires no setting-up, has no valves or leveling bottle to manipulate.

The FYRITE measures CO_2 directly by the fundamental method of chemical absorption. Consequently, the reading is independent of voltage, humidity, temperature, or atmospheric pressure conditions.

Comes complete with chemical charge good for at least 300 readings. Replacing chemical merely requires removing four screws that hold top assembly in place.

Write for Bulletin 805

BACHARACH Industrial Instrument Company

200 N. Braddock Ave. • Pittsburgh 8, Pa.

CIRCLE 23 ON READER-SERVICE CARD

ICS PEOPLE IN THE NEWS

MINNEAPOLIS-HONEYWELL announces appointment of *K. Russell Knoblauch* as market sales manager for the Industrial Products Group consisting of the Brown Instruments, Rubicon, Valve, Industrial Systems, Heiland, and Fall River Divisions.

K. R. KNOBLAUCH
Minneapolis-Honeywell

R. O. BULLARD
Baldwin-Lima-Hamilton

BALDWN-LIMA-HAMILTON announces election of *Robert O. Bullard* as vice president and general manager of the Electronics and Instrumentation Division.

W. H. REYNOLDS
Aminco

L. FREEMAN
Aminco

AMERICAN INSTRUMENT CO. announces election of *William H. Reynolds, Sr.*, as chairman of the board and *Leopold Freeman* as president.

EMBREE ELECTRONICS CORP., West Hartford, headed by *John M. Embree* is a new firm which will soon market a line of products related to analog computers.

MARSHALLTOWN

DIAPHRAGM GAUGE FOR ACCURATE PRESSURE MEASUREMENT IN OUNCES OR INCHES OF WATER

Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

Available in standard dials (reading in inches of water) 0-15" -0-30" -0-60" -0-100" -0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

Write for details and price. LOOK TO MARSHALLTOWN FOR ONE OF THE MOST COMPLETE LINES OF INDICATING PRESSURE GAUGES MADE!

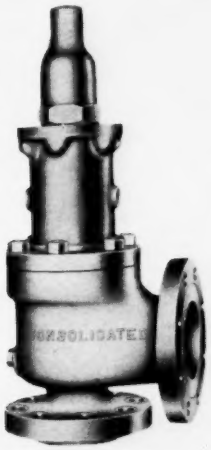
MARSHALLTOWN MFG. COMPANY

MARSHALLTOWN 3, IOWA

CIRCLE 24 ON READER-SERVICE CARD

top

CONSOLIDATED SAFETY RELIEF VALVES have a special "O" Ring Seat Seal that stops leakage completely



Consolidated Safety Relief Valves are available in both Standard and Balanced Bellows design for extreme corrosive applications.

tightness

The Seal is a resilient ring set in the valve disc. It maintains no-leak tightness by contact with a specially curved seating surface on the valve nozzle, yet does not carry the seat load imposed by the valve spring.

Tightness is maintained at operating pressures far closer to set pressure than with metal-to-metal seats alone. Tight closure is as efficient after "simmer" as on normal blowdown. Piping strains are absorbed far better by the resilient seal than all-metal seating. If the tough seal is ruined by entrained abrasives, replacement is easy. Seals are available in materials that resist corrosive fluids. Maintenance costs are greatly reduced.

Standard Consolidated Safety Relief Valves have an eductor tube that removes pressure from the closed bonnet. Only the spring controls valve action. You get guaranteed capacity ratings and highest dependability—absolute protection for personnel and equipment. Additionally, there is the economy of converting the Standard valve to the Balanced Bellows type in your own shop. Get complete details. Write for Bulletin 1940.

MANNING MAXWELL & MOORE INC. TRADE MARK

CONSOLIDATED SAFETY RELIEF VALVES

A product of

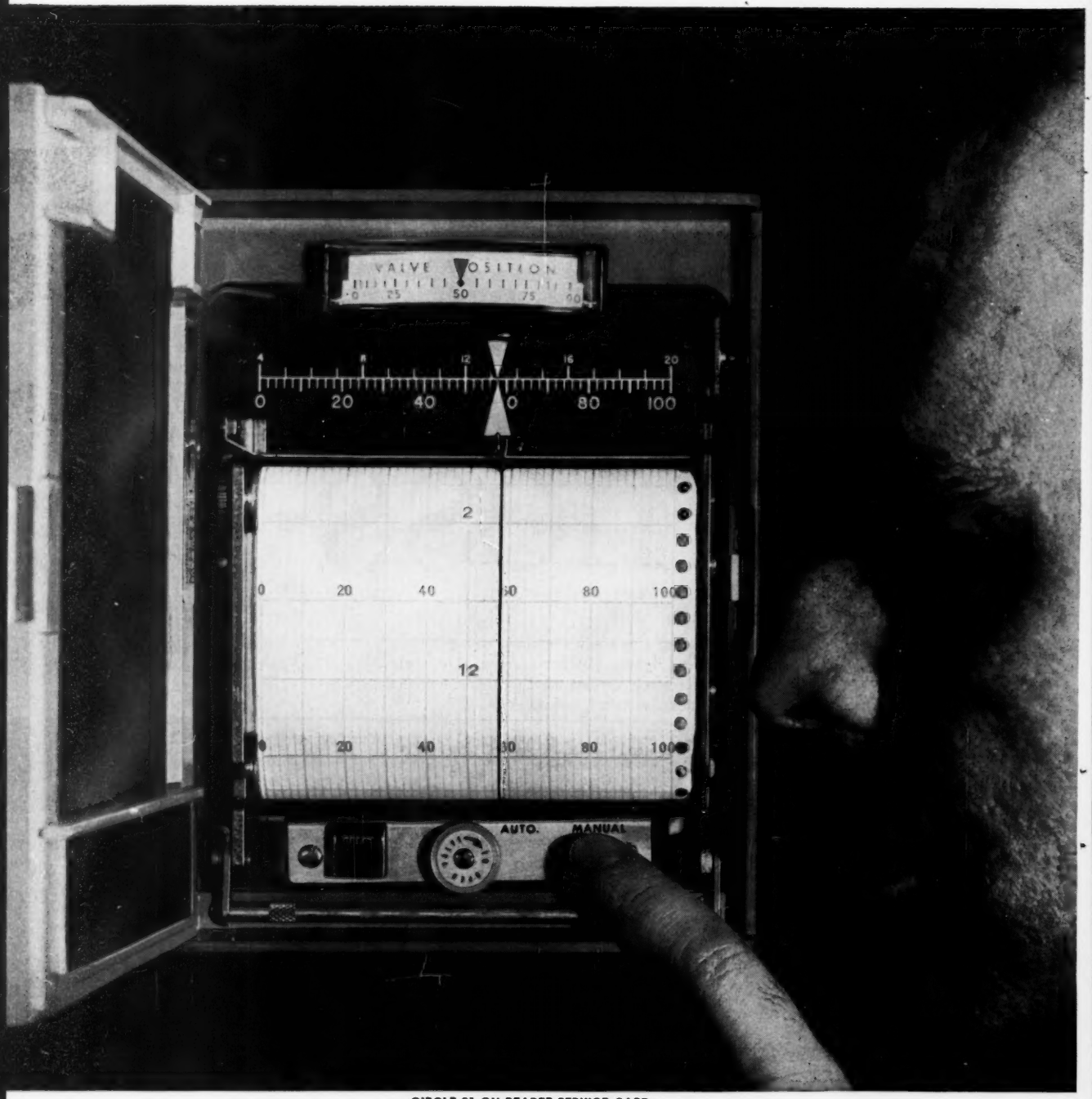
MANNING, MAXWELL & MOORE, INC.

Valve Division • Tulsa, Oklahoma

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 20 ON READER-SERVICE CARD

New *ElectriK Tel-O-Set*... needs in a single compact



CIRCLE 21 ON READER-SERVICE CARD

everything an operator control station

This Honeywell electric control station meets all of your requirements for operator convenience.

One compact case houses *every* function the operator needs to supervise a control loop: indication of process variable and set point on the same scale; the controls needed to switch from automatic to manual; controls for manual control; and indication of valve position.

The *ElectriK Tel-O-Set* control station assures easier bumpless transfer than ever before available because there's no need to "line up" or "match" pointers. A null balance indicator eliminates guesswork, and the transfer doesn't have to be hurried since the valve remains under control during the transfer.

You can also order the controller with the proportional band, rate, and reset adjustments on the front of the panel conveniently located below the control station, or at the rear of the panel.

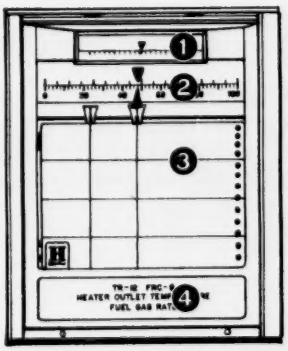
These are just a few of the features that make the new *ElectriK Tel-O-Set* control system an outstanding value. Your Honeywell engineer can give you complete details. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Fall River, Massachusetts.

75th YEAR PIONEERING THE FUTURE

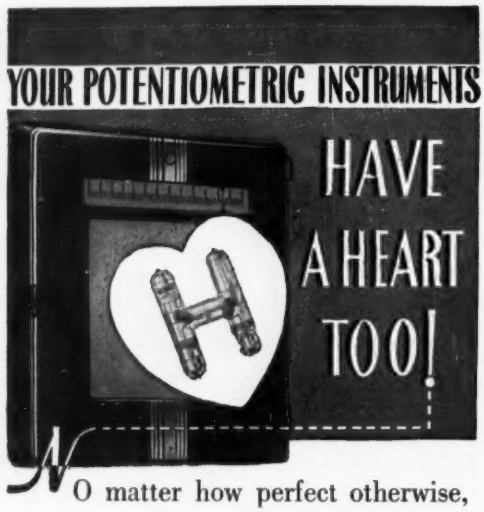
Honeywell

First in Control SINCE 1885



1. Valve position indicator continuously indicates controller output when on automatic control.
2. Set point index is conveniently located on same scale as process-variable pointer; you can see from a distance any deviation of variable from set point.
3. Rectilinear 4-inch calibrated chart is easy to read. At standard chart speed, four hours of recording is always visible. Unit has daily chart tear off or 30-day rewind. Both recorder and control station take the same 5½" x 6" panel cutout.
4. You get bumpless switching from automatic to manual control because you don't have to match pointers. In the balance position, the valve position indicator is part of a null circuit that compares controller output and manual output. When indicator reads 50%, both outputs are perfectly matched.

CIRCLE 21 ON READER-SERVICE CARD



NO matter how perfect otherwise, the human organism isn't much good without a dependable heart. The same is true of your automatic temperature and pH control instruments.

The "heart" of most such instruments for the past quarter century has been the Eplab Standard Cell. It is a "yardstick" for translation of voltage to temperature or pH. The first American commercial cell of its type, constantly improved by research, it is "as standard as sterling".

Get ACCURATE temperature or pH control with potentiometers and make sure the standard cells are EPLAB.

The Eppley Laboratory, Inc. 2 Sheffield Ave., Newport, R. I.

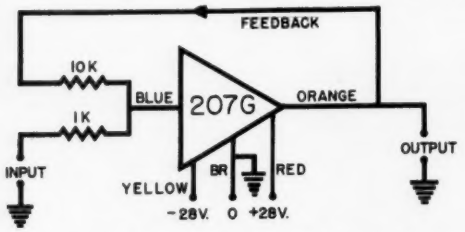
EPLAB *Standard* CELLS
FOR POTENTIOMETRIC INSTRUMENTS
"As Standard as Sterling"

CIRCLE 19 ON READER-SERVICE CARD

ICS BRIEFS

A-c Voltage Amplifier

Circuit shows the best configuration for a lightweight, simple system of minimal size . . . The typical data below applies to the circuit at 3.0 KC: Open



loop gain—40 db; closed loop gain—20 db; gain stability —50°C to +50°C—±3%; bandwidth—DC to 20 KC; input impedance—1000 ohms; output voltage (10K load)—2.2V Max. RMS; output impedance —under 300 ohms; noise at output—under 100 microvolts . . . (*From new 2-page Price List P-59207G, Taber Instrument Corp., Electronic Div.,* 107 *Goundry St., North Tonawanda, N. Y.*)

FOR THIS LITERATURE CIRCLE 166 ON READER-SERVICE CARD

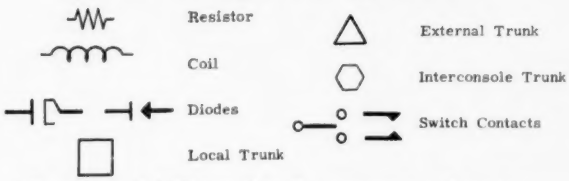
Solid-State Computer

The General Mills 2003 computer is a medium size, medium speed, general purpose computer tailored to meet the needs of consumers who require high performance and reliability at moderate cost . . .

Speed—basic clock rate of 50 kilocycles. Execution times for common arithmetic operations (including memory access time) are: Addition—80 microseconds, subtract—100 microseconds, multiply—820 microseconds, divide—940 microseconds. All other arithmetic operations require 80 microseconds . . . In addition to a 4,096 word magnetic core memory, the General Mills 2003 computer contains two 64-word buffer memories and a 1-word buffer register for conversing with external devices. These buffers enable exchange of information and arithmetic operations to proceed simultaneously . . . (*From new 4-page bulletin General Mills, Mechanical Div.,* 1620 *Central Ave., Minneapolis* 13, *Minn.*)

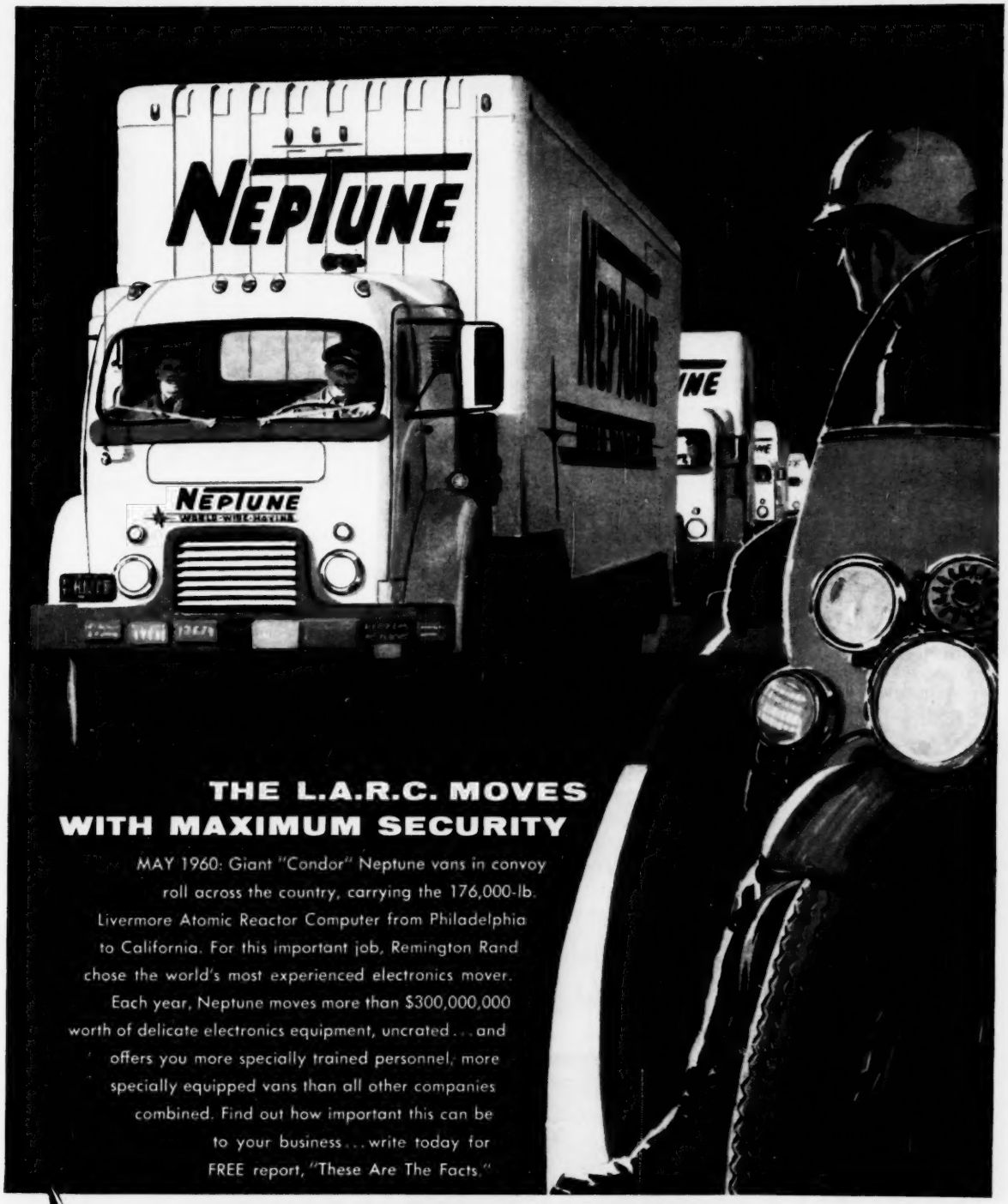
FOR THIS LITERATURE CIRCLE 167 ON READER-SERVICE CARD

EASE Template Symbols



(*From new EASE template for computer schematics, Beckman/Berkeley Div.,* 2200 *Wright Ave., Richmond* 3, *Calif.*)

FOR THIS LITERATURE CIRCLE 168 ON READER-SERVICE CARD



THE L.A.R.C. MOVES WITH MAXIMUM SECURITY

MAY 1960: Giant "Condor" Neptune vans in convoy roll across the country, carrying the 176,000-lb. Livermore Atomic Reactor Computer from Philadelphia to California. For this important job, Remington Rand chose the world's most experienced electronics mover. Each year, Neptune moves more than $300,000,000 worth of delicate electronics equipment, uncrated . . . and offers you more specially trained personnel, more specially equipped vans than all other companies combined. Find out how important this can be to your business . . . write today for FREE report, "These Are The Facts."

NEPTUNE

ELECTRONICS MOVING DIVISION
WORLD HEADQUARTERS • New Rochelle, N. Y.

WORLD-WIDE MOVING

EASTERN Riverside Drive at 134th St. New York City
SOUTHERN Billings Street Norfolk, Virginia
CENTRAL 2910 West Montrose Ave. Chicago, Illinois
WESTERN 3400 Broadway Oakland, California

Warehouses and facilities from coast to coast • Offices and Agents throughout Europe, South America, Pacific Islands and Far East

CIRCLE 25 ON READER-SERVICE CARD

DEKORON ARMORED* INSTRUMENT HARNESS

4 + 4 = 16

TUBE MATERIALS + TUBE CONSTRUCTIONS = DIFFERENT TYPES

Yes, *four* different core tubing materials (copper, aluminum, polyethylene, nylon) combined with *four* distinct types of armoring give you *sixteen* different types of Dekoron Armored Instrument Harness from which to choose.

Designed specifically for instrument harness application, special Moore-Loc armor construction has almost twice the pull-apart resistance of ordinary armoring . . . has cord packing for extra resistance to moisture and fume penetration.

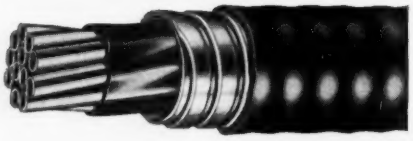
There's at least one best type of Dekoron for your installation. We help *you* select it; we're unbiased because we make all types. Now go Dekoron 100% for all your tubing needs. Think of Dekoron first . . . to last. That's *Dekoron—America's Premier Line of Armored Instrument Harness.* A-314A

CONSTRUCTIONS

TYPE VA

For Impact and Corrosion Resistance. Core tubes with vinyl sheath covered with Moore-Loc modified-square-lock construction armor with cord packing.

TYPE VAV



For Impact and Maximum Corrosion Resistance. Same construction as Type VA (*above*) but with outer vinyl sheath. 24-gauge galvanized steel armor gives maximum pull-apart and impact resistance.

TYPE A

For Impact Resistance in Dry Locations. Core tubes are wrapped in vinyl-impregnated insulating tape. Tape insulates and cushions core tubes inside metal armor.

TYPE AV

For Corrosion and Impact Resistance. Same construction as Type A (*above*) but with outer vinyl sheath. All four constructions available with metal or plastic core tubes.

*Licensed under Patent 2,578,280

Dekoron® products QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & COMPANY

DEKORON PRODUCTS DIVISION • MANTUA, OHIO

CIRCLE 15 ON READER-SERVICE CARD

Proportion of population in professional, technical and kindred occupations in USA has increased as follows: 1900—5%; 1950—8%; 1955—9%; 1958—11%.

Nearly 2000 institutions of higher education were listed by US Office of Education for academic year 1958-59; 30% offer less than a 4-year program leading to a Bachelor's degree. Nearly 60% of all students were in publicly controlled institutions.

Industrial electronics market will be $8-$10 billion by 1970, says G. Root of Lockheed Aircraft; industrial electronics market will be $3.4 billion in 1970 says D. Hull of Electronic Industries Association.

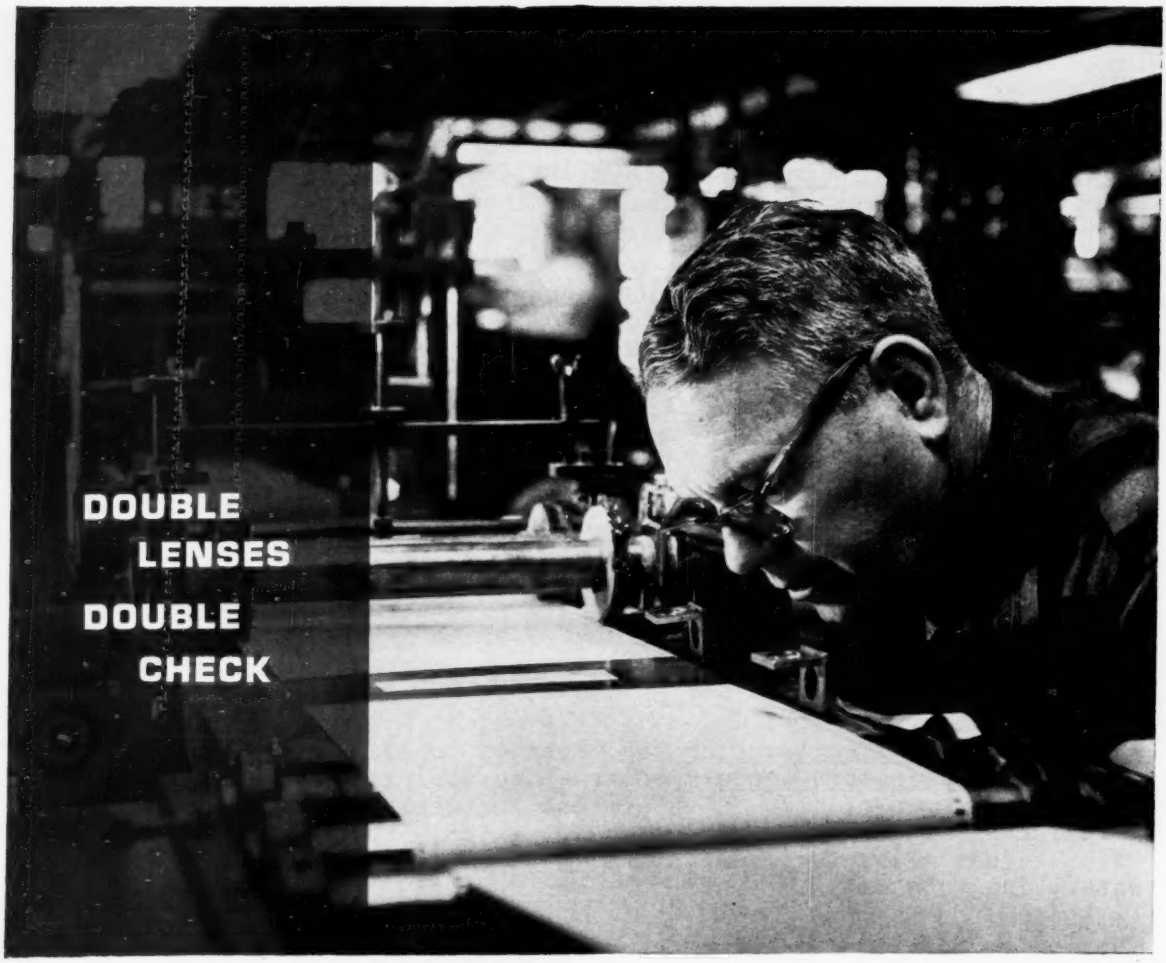
Electronics industry, with commercial and industrial business increasing by 250%, should boost its annual volume to the $25-billion mark by 1965, predicts D. Sarnoff, RCA. Computers, controls and communications should grow from present $2-billion-a-year to about $7 billion by 1965. All other major areas of electronics (now a $14 billion enterprise) will contribute to the growth pattern.

Another 10,000-mile-plus year was recorded in 1959 by members of the Pipe Line Contractors Assoc. Construction was broken down as follows: natural-gas transmission, 6,957 miles; natural-gas gathering, 732 miles; natural-gas distribution, 1,107 miles; crude trunk lines, 547 miles; crude gathering, zero miles; products lines, 864 miles; and water lines, 56 miles, reports Oil Gas Journal.

Chemical production and research facilities costing an estimated $1.657 billion will be constructed in the United States during 1960 and 1961 says the Manufacturing Chemists' Association. Approximately $1.344 billion were completed in 1959. The three-year expenditure of approximately $3.002 billion represents a total of 820 projects by 318 companies in 458 communities of 42 states. Leading the list in this year's survey is the construction of production facilities for general inorganic chemicals with a total of $686.219 million. General organics are second with $674.508 million, followed by petrochemicals, $454.535 million; plastics and resins, $450.080 million; laboratories, $220.485 million; fertilizer chemicals, $116.427 million; synthetic fibers, $101.300 million; special metals, $85.920 million, and synthetic rubber, $45.150 million. A ''miscellaneous'' grouping accounts for the remaining $167.046 million.

Factory sales of all types of electron tubes totaled approximately $870 million in 1959, an increase of nearly 12% over 1958 level, reports D. Y. Smith of RCA. Receiving tubes accounted for nearly $370 million; industrial and military tubes represented approximately $250 million; with balance of about $250 million in TV picture tubes. Greatest expansion was in industrial tube sales which rose about 20% over 1958.

Japanese penetration of American transistor and transistor radio market now equals about 25% of domestic output, says D. Hull of Electronic Industries Association.



. . . for the precise calibration that means RECORDING CHART DEPENDABILITY

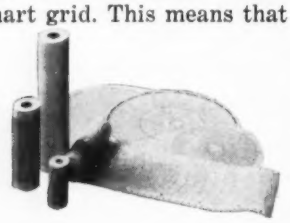
Charlie Robinson, our pressroom supervisor, is making a careful chart calibration check in the picture above. He does this often.

To make this test Charlie uses two engraver's glasses, a special templet . . . and the 50 years of chart printing experience that stands behind every GC Recording Chart.

What this test involves is making sure that the center line of the circular punches on a GC Strip Recording Chart is always the same distance — the *correct* distance — from the zero line of the chart grid. This means that a 25 psi recording at the end of a process, for example, will have the same value as a 25 psi recording at the start.

Take rigid inspection standards like these — and add repeated paper and ink tests, continuous humidity control in production and storage areas, and speed of printing and delivery. You'll see why more than 5,000 chart users rely regularly on GC dependability.

GC stocks more than 15,000 different chart types. We design and print charts for special purposes. Why not send now for the GC Stock List and for specific sample charts?



RECORDING CHARTS

Distributed by:
TECHNICAL SALES CORPORATION
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A Subsidiary of
GRAPHIC CONTROLS CORPORATION
Buffalo 10, N. Y.

CIRCLE 28 ON READER-SERVICE CARD

I&CS EVENTS

June 22-24

1960 Conference on Electronic Standards and Measurements, National Bureau of Standards Laboratories, Boulder, Colorado. For information write Herbert Finke, Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y.

July 28-29

Denver Research Institute's 7th Annual Symposium on Computers and Data Processing, Stanley Hotel, Estes Park, Colorado. For information write W. H. Eichelberger, University of Denver, Denver 10, Colorado.

August 1-3

4th Global Communications Symposium, Statler Hilton Hotel, Washington, D.C. For information write Ralph L. Clark, Office of Director of Defense Research and Engineering, Washington 25, D.C.

August 1-5

Gordon Research Conferences on Instrumentation, Colby Junior College, New London, New Hampshire. For information write Dr. W. George Parks, Gordon Research Conferences, Dept. of Chemistry, University of Rhode Island, Kingston, Rhode Island.

August 1-12

Summer Program on Modulation Theory and Systems, on campus of Massachusetts Institute of Technology. For information write Elie J. Baghdady, Dept. of Electrical Engineering, MIT, Cambridge, Mass.

August 3-6

Infrared Spectroscopy Institute Gas Chromatography Session, on campus of Fisk University. For information write Infrared Institute, Fisk University, Nashville, Tenn.

August 24-25

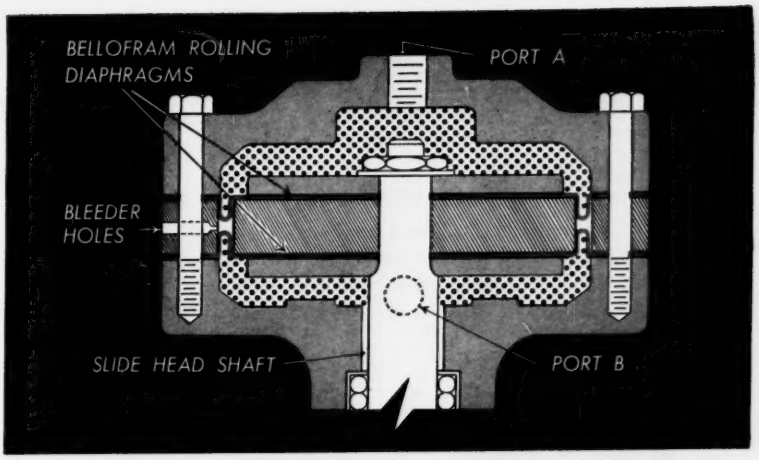
1960 Cryogenic Engineering Conference, on campus of University of Colorado. For information write K. D. Timmerhaus, Dept. of Chemical Engineering, Boulder, Colorado.

August 29-31

Appalachian Gas Measurement Short Course, on campus of University of West Virginia. For information write R. E. Hanna, School of Mines, University of West Virginia, Morgantown, West Va.

September 7-9

1960 Joint Automatic Computer Conference, on campus of Massachusetts Institute of Technology. For information write JACC Chairman William D. Archibald, Energy Control Co., 5 Beekman St., New York 38, N. Y.



Air pressure entering double-acting cylinder at Ports *A* and *B* actuates slide head shaft, which controls positioning of upper electrode. Sensitive low inertia response is achieved by two frictionless Bellofram Rolling Diaphragms. Bleeder holes maintain a pressure differential.

Frictionless Rolling Diaphragms Insure Fast Follow-up for Welder

PROBLEM: To design, for use in an automatic welding machine, a pneumatic actuator for positioning the upper electrode in response to expansion or contraction of the weld nugget. Sensitive, frictionless movement was mandatory to provide instantaneous reaction to momentary changes in nugget dimensions.

SOLUTION: Federal Machine & Welder Company's designers specified a double-acting air cylinder with two Bellofram Rolling Diaphragms, each molded from a dacron fabric impregnated with a nitrile elastomer.

With no mechanical spring gradient, no break-out friction effects, and low hysteresis, these rolling, non-porous membranes instantly translate pressure changes into movement of the electrode control head. Although very sensitive to pressure variations, they are capable of sustaining high working pressures, because the force experienced on the narrow convolution is only a small fraction of the total force applied over the effective pressure area.

Operating between wide temperature ranges, these Bellofram Rolling Diaphragms provide a flex life of millions of cycles, yet do not require lubrication or close machine fits for piston and cylinder.

Bellofram Rolling Diaphragms are free positioning and friction-free. They roll off the piston sidewall and onto the cylinder sidewall in a smooth, continuous motion.

WHAT IS YOUR PROBLEM?

If conventional bellows, O-rings, cup packings, etc., fall short of your requirements, Bellofram Rolling Diaphragms may be the answer. Special types can be designed for use with almost any gas or fluid in actuators, pumps, instruments, seals, accumulators, fluid dampers, etc.

OPERATING LIMITS

Operating Pressures: 1 inch H_2O to 500 psi (up to 1200 psi in some cases).

Operating Temperatures: −85°F. to +550°F. (from −120°F. to +700°F. in some cases).

Cylinder Bore Sizes: .25 to 12 inches.

Effective Pressure Area: .028 to 108 square inches.

Total Stroke Capabilities: .01 to 12 inches.

Sidewall Thickness: .008 to .035 inches.

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nothing rolls like a

Bellofram®

rolling diaphragm

BELLOFRAM CORPORATION, 31 BLANCHARD RD., BURLINGTON, MASS.

BRowning 2-2100 Mission 3-9000 Teletype No. Burl., Mass. 166

®Reg. trademark U.S.A. and foreign countries • Bellofram Rolling Diaphragms are protected by U.S.A. and foreign patents.

ICS BRIEFS

Conversion Factors

The primary emphasis has been placed on the multiplication factors involved in converting the fundamental electrical and magnetic units. However, because practicing engineers often have no work with data

hectares	acres	2.471
"	sq feet	1.076×10^5
hectograms	grams	100.0
hectoliters	liters	100.0
hectometers	meters	100.0
hectowatts	watts	100.0
henries	millihenries	1,000.0
horsepower	Btu/min	42.44
"	foot-lbs/min	33,000.
"	foot-lbs/sec	550.0
horsepower (metric) (542.5 ft lb/sec)	horsepower (550 ft lb/sec)	0.9863
horsepower (550 ft lb/sec)	horsepower (metric) (542.5 ft lb/sec)	1.014
horsepower	kg-calories/min	10.68

from other branches of engineering, frequently-used conversion factors for the following basic types of units are also included; area, angles, angular acceleration, angular velocity, flow of water, force, heat and energy, length, linear acceleration, linear velocity, mass, power, pressure, temperature, volume, weight. . . . (*From new* 24*-page pocket-size Circular* 1956, *Automatic Electric Co., Northlake, Ill.*)

FOR THIS LITERATURE CIRCLE 169 ON READER-SERVICE CARD

High-Speed Low-Level D-C Amplifier

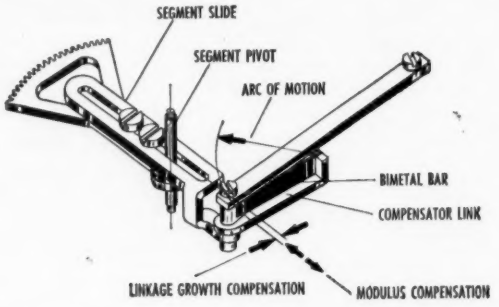
The Model 361 DC Amplifier represents a major breakthrough in amplification technology. A completely new input circuit (patent pending, Redcor Development Corp.) incorporated in the Model 361 pro-

vides two unusual features: (1) the common mode rejection ratio increases in direct proportion to the amplifier gain and is insensitive to line unbalance, and (2) the input impedance from either input terminal to any other terminal is 1,000 megohms minimum. These features allow wide-band amplification with common mode rejection equal to that of narrow-band amplifiers . . . Outstanding features (include) differential input impedance (of) 10^9 ohms, either input, at DC . . . . (*From new* 2*-page flyer, Packard Bell Computer, a sub. of Packard Bell Electronics,* 1905 *Armacost Ave., Los Angeles* 25*, Calif.*)

FOR THIS LITERATURE CIRCLE 170 ON READER-SERVICE CARD

Ultra High Pressure Test Gauge

Precision of 1/10 of 1% of full scale reading has been extended to pressure gauges in the 100,000 psi range . . . Significant in the design of this new laboratory instrument is a unique helical tube. An exclusive Heise process is used to produce a one piece tube of stainless steel which is precisely formed to the correct oval section at the working portion. This portion is then coiled to produce a helical tube and the unformed ends are positioned to serve as the gage outlet tube and as a bleeder device. Internal connections which are normally a source of error and possible failure in high pressure gages are eliminated entirely . . .



The tube is positioned within the gauge by a rigid mounting on the socket casting which is similar in design to the base of the standard Heise "Integral Movement" a unit in which all moving parts of the gauge are related and isolated from external forces . . .

Another recent development is the "Heise Thermal Compensator". This device makes possible continuous pressure readings through a temperature change of 100°F without manual resetting or thermal error computation. The thermal properties of a bimetal bar are used to automatically correct calibration error due to temperature variations . . . . (*From new* 2*-page flyer Heise Bourdon Tube Co., Inc., Brook Rd., Newtown, Conn.*)

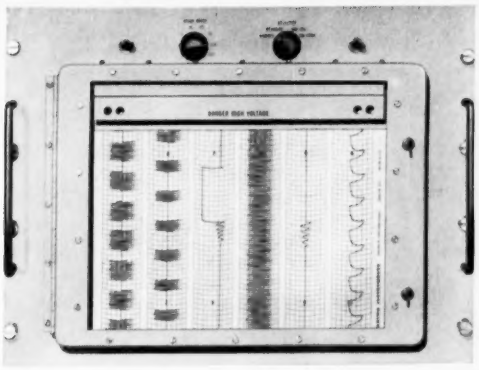
FOR THIS LITERATURE CIRCLE 171 ON READER-SERVICE CARD

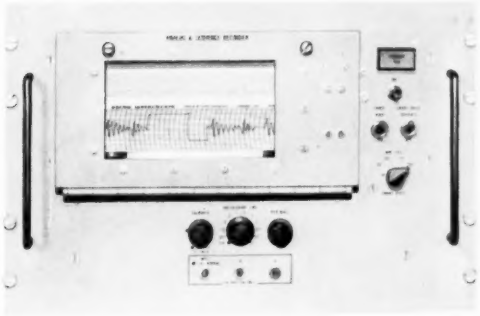
Time Analyzer

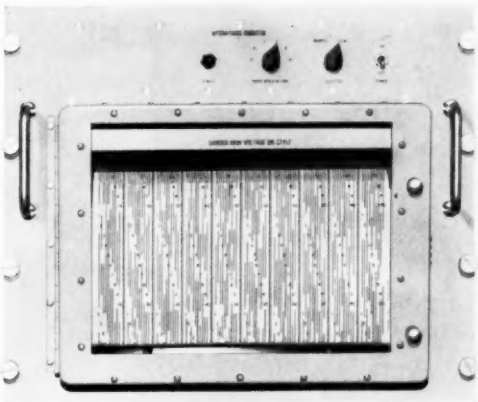
Most Eldorado instruments are self-contained in a compact frame which may be either rack mounted or placed directly on a bench. Systems consist of multiple frames which are stacked one above the other in standard cabinet enclosures . . . The 0900 System counts and stores information from 32 channels for the statistical analysis of distribution of nuclear events in time. The analyzer system is divided into two parts—a program unit and a scaler unit. The scaler unit consists of 32 identical scaler channels, each having two scale-of-10 decimal counting units and a 4-digit mechanical register. The program unit comprises circuitry necessary to establish channel width, cycle delay, experiment time and calibration . . . . (*From new* 8*-page Bulletin D-*100 *Eldorado Electronics,* 2821 *Tenth St., Berkeley* 10*, Calif.*)

FOR THIS LITERATURE CIRCLE 172 ON READER-SERVICE CARD

CIRCLE 29 ON READER-SERVICE CARD ⟶







in direct writing recording systems

only Brush designs specifically for mil specs

From every nut and bolt to the shipping crate, fully militarized Brush Direct Writing Recording Systems are *originally* built to meet military specifications.

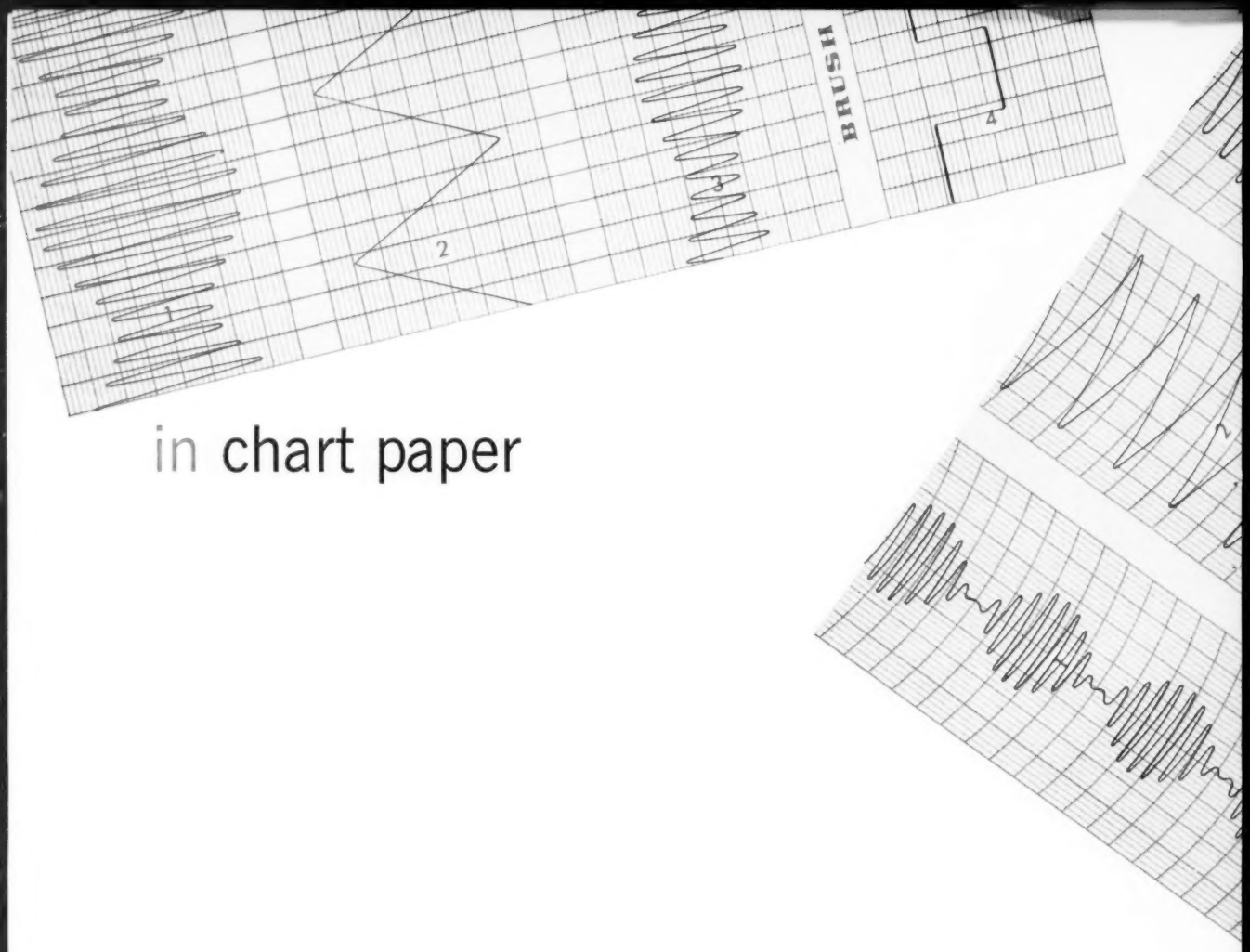
That's why they are performing every imaginable task of data acquisition and recording at U. S. and NATO installations throughout the world. These electric writing systems have proved their unexcelled reliability . . . from the Operations Monitor that will record 120 separate operations at the instant they occur . . . to the Analog and Sequence Recorder that simultaneously records both analog data and sequential events. And, they are built for maximum performance in the hands of non-technical personnel.

Brush equipment is already at work putting evaluation data in writing for a whole new generation of weapons. When the weapons become operational, Brush MIL Recorders are a vital part of the system. This experience is unique in the industry. *Before* prototype design becomes a problem—call, write or wire Brush for complete details.

brush INSTRUMENTS

DIVISION OF

37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO



in chart paper

there is a difference

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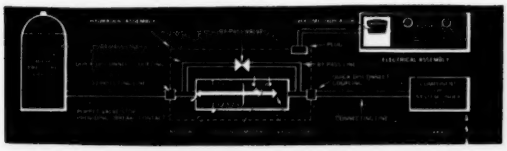
Only Brush Chart Paper is designed as an integral component of precisely engineered Brush Direct Writing Recording Systems. The full potential of these systems cannot be realized unless *all* of the original components are utilized. They're engineered as a *total* entity. Imitation papers cannot match the precision ruling, dimensional stability and super-smoothness of Brush Chart Paper. Take no chances—specify *Brush* and you can rely on your records being accurate, permanent, easily read and easily reproduced. Stocks available from strategically located branches and sales representatives throughout the United States and Canada.

Write for samples of actual tracings on Brush Chart Paper. Ask for "Check the Record".

Hydraulic Leakmeter Model 400

The component or system to be tested for leakage is connected to a source of high pressure liquid from which any leakage is replaced. The hydraulic assembly to the Leakmeter is installed in the connecting line. When the built-in by-pass valve is open, the leak flow goes around the bellows without affecting it. However,

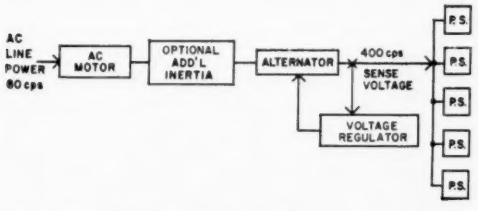


closing the by-pass valve forces the leakage to pass through the leakmeter, expanding the bellows. A rectilinear potentiometer senses its position and produces a voltage which is proportional to the volumetric displacement of the bellows. This voltage is then indicated by the volume indicator on the remotely mounted electrical assembly. A timer is started simultaneously with the closing of the by-pass valve . . . If there is a leak, even a minute one, the bellows is displaced and the contact broken. The red light will then illuminate, signalling the presence of a leak . . . (*From new 4-page Bulletin 4-1 Convair Instruments/Convair, a Div. of General Dynamics Corp., 3595 Frontier St., San Diego 10, Calif.*)

FOR THIS LITERATURE CIRCLE 173 ON READER-SERVICE CARD

Application of Precise-Power Sets to Large Electrical Systems

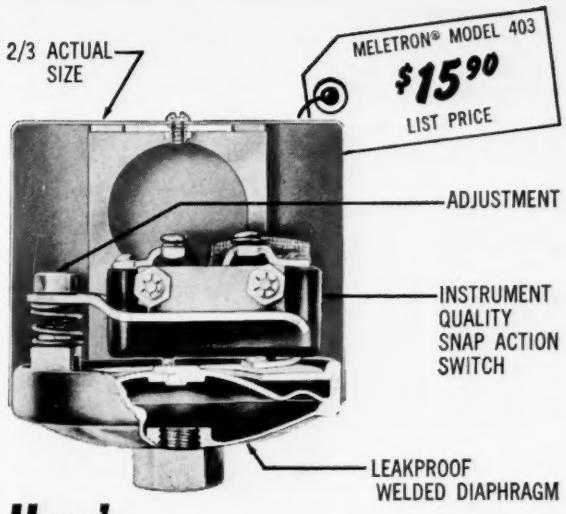
A Precise-Power Set may be defined as a rotary electro-mechanical system, usually regulated and/or controlled by static circuitry, which performs one or more of the following functions: (1) Isolates the DC



power system from power-line voltage transients . . . (2) Performs the conversion to DC (regulated or unregulated) directly, in a more economical manner than by any other method.

The Problem—At each of eight racks, 7 different voltage levels are required by a Transistorized Digital Computer . . . Here is the recommended circuit . . . A modern Precise-power motor-alternator set followed, in this case, by completely unregulated, "stiff" brute-force supplies. Note that only one regulating circuit is employed in the entire system . . . in the precise-power alternator output-voltage regulator . . . (*From new 8-page Bulletin ENG-5900, Electric Specialty Co., 211 South St., Stamford, Conn.*)

FOR THIS LITERATURE CIRCLE 174 ON READER-SERVICE CARD



Here's the Simplest Diaphragm Pressure Switch

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	LINKAGES & BEARINGS which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements	LIQUID SWITCHING ELEMENTS which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	ACCORDION BELLOWS which make the pressure switch sensitive to vibration.

ASK FOR NEW CATALOG 9-PS FREE

PRESSURE SWITCH DIVISION

Barksdale valves

5125 Alcoa Avenue, Los Angeles 58, California

CIRCLE 31 ON READER-SERVICE CARD

← **CIRCLE 30 ON READER-SERVICE CARD**

IDEAL

Thermo-Tip®

RESISTANCE SOLDERING TOOLS

NEW easier-to-handle "Pistol-Grip" Style

Speed Assembly Line Work

up to

42%*

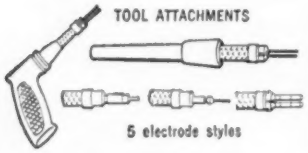
greater reliability for soldering pin-type plugs, aircraft connectors, wire-to-wire, terminals, instruments, printed circuits, electronic systems and parts.

- higher soldering speed reduces costs
- higher-quality connections — fewer rejects
- better, more accurate work on miniaturized assemblies
- light, easy-to-handle — women can use all day without fatigue
- entirely safe, heat only on contact — no operator burns

* Proved by on-the-job comparisons . . . ask for Bulletin C217

COMPLETE LINE OF EQUIPMENT FOR ALL NEEDS

TOOL ATTACHMENTS



5 electrode styles

3 POWER UNIT SIZES

500-Watt 250-Watt 125-Watt

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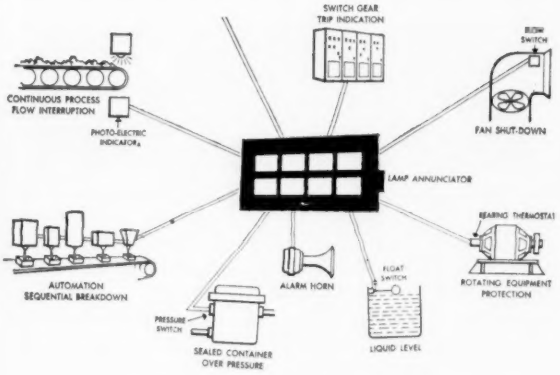
CIRCLE 32 ON READER-SERVICE CARD

Annunciators

The Edwards Company is the oldest and largest manufacturer of electric signaling devices for control, communication and protection . . . The latest results of Edwards design, research and development is a completely new line of industrial lamp annunciators. Annunciators indicate visually and audibly any ab-



normal condition or change in status of pressure, temperature, opening of circuit breakers, high or low level, power or equipment failure or any break in an electrical circuit. Typical applications are for supervision of generators, turbines, compressors, pump supervision, switch-boards, control centers and all types of industrial processes or equipment supervision . . . (*From new 24-page Bulletin A-20, "Industrial Lamp Annunciator Systems," Edwards Co., Inc., Norwalk, Conn.*)

FOR THIS LITERATURE CIRCLE 175 ON READER-SERVICE CARD

Instrument Bearings for Miniaturization

Load rating for each bearing is given in terms of "C," the "basic dynamic capacity" of the bearing in pounds. This is calculated from empirical formulae, and is defined as the radial load which ninety percent of a given group of identical bearings will sustain for one million revolutions before first evidences of fatigue

Static Load Ratings (in pounds) of typical bearings are as follows:

Bearing No.	Balls	Radial Capacity	Thrust Capacity
3010	5 1/32	8	8
2210	6 1mm	17	21
2460	5 1/16	32	52
2740	6 1/16	46	63
2810	8 1mm	29	27

. . . It should be noted that calculations of dynamic load ratings do not include variables such as lubrication, retainer design, speed/time relationships, ambient temperatures, and mounting conditions. These may considerably alter the foreseeable life of a bearing . . . (*From new 16-page Form 485, Reed Instrument Bearing Co., Div. SKF Industries, Inc., 4241 Redwood Ave., Los Angeles 66, Calif.*)

FOR THIS LITERATURE CIRCLE 176 ON READER-SERVICE CARD

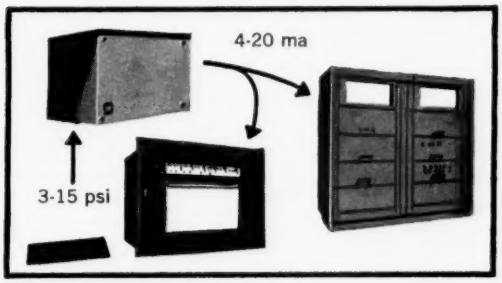
Whether you're controlling or recording

. . . now you can mix electric and pneumatic components

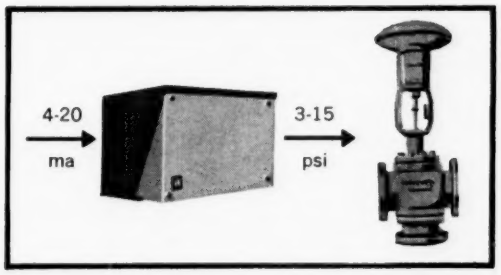
The introduction of Honeywell's complete line of *ElectriK Tel-O-Set* instruments makes electric and pneumatic components completely compatible.

Now you can add the advantages of electric instrumentation to your present *pneumatic* systems. Or, if you are designing a new system, you can use your favorite pneumatic components in an otherwise completely electric system.

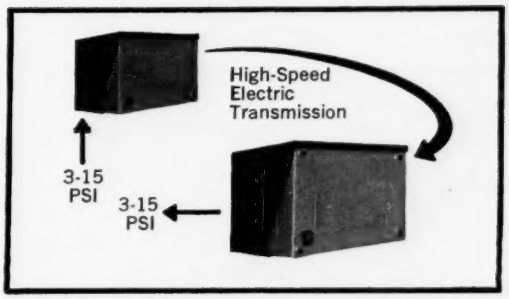
Here's an example: You have a pneumatic system but want to record a key variable on an *ElectroniK* strip chart recorder. The answer is an *ElectriK Tel-O-Set* pressure-to-current (P/I) transducer which converts the standard 3-15 psi signal to a standard 4-20 ma signal which can be fed to a data logger or computer as well as to a potentiometer.



Now let's assume that you are putting in an all-electric system but prefer pneumatic control valve operators. Here the answer is an easily installed *ElectriK Tel-O-Set* current-to-pressure (I/P) valve operator which converts the standard 4-20 ma signal to a standard 3-15 psi signal.



Used separately, *ElectriK Tel-O-Set* transducers allow you to easily intermix electric and pneumatic components. Used together, in pneumatic loops, they give you long distance high-speed transmission and eliminate the lags inherent in long runs of pneumatic tubing.



These twins have a calibrated accuracy of ± ¼% of span. They're completely transistorized for long, reliable service. Only two wires, forming a series circuit between the two transducers, are needed to carry the signal as well as the system's power. Line power is not required in the field.

Transducers are just part of the story. *ElectriK Tel-O-Set* transmitters are available to convert temperature, pressure, differential pressure, and other process variables into a current signal. To complete your system, you have a wide choice of different types of electric control . . . readouts including meters, indicators, and large case recorders . . . and final control elements.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne & Windrim Avenues, Phila. In Canada, Honeywell Controls Limited, Toronto 17, Ont.

Honeywell

First in Control

SINCE 1885

75th YEAR

PIONEERING THE FUTURE

CIRCLE 27 ON READER-SERVICE CARD

REMOTE BULB, INDICATING TEMPERATURE CONTROL E32N

Featuring Control Point Accuracy Equivalent to Individually Calibrated Instruments

The **UNITED ELECTRIC** Type E32N Temperature Control is a uniquely designed instrument that is used to control and indicate temperatures of gases, liquids or hot plates over wide ranges. This unit contains a 12-inch scale for easily read visual indications. It is possible to replace the thermal unit in the field without any loss of calibration accuracy.

Temperature Ranges....	−150°F. to 150°F., 70°F. to 370°F., 100°F. to 650°F. Read temperature on continuous, 12-inch indicating scale that rotates against a fixed index pointer in a vertical and centered location.
Switch Ratings.....	Up to 15 amps. at 115 or 230 volts A.C. 20 amp. A.C. or D.C. switches also available.
Switch Types.....	N.O., N.C., or Double Throw — no neutral position.
On-Off Differential.....	Approximately 1.0°F. or 2.0°F. dependent on model.
Adjustment.....	Calibrated dial rotated against a fixed index.
Calibration.....	Calibrating mechanism permits precise matching of scale to individual tolerance errors of thermal assemblies.
Compensation.....	Automatic compensation for ambient temperatures.

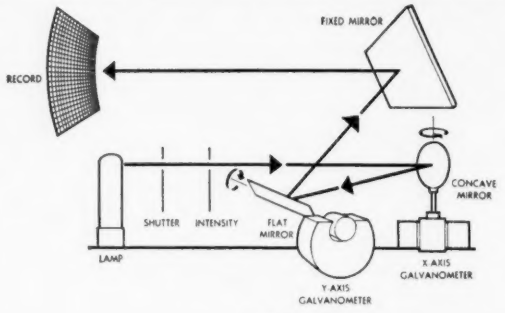
UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. For applications requiring custom-built units or modified standard units, call upon a UE application engineer for recommendations. Complete data is available for the Type E32N as well as for all standard UE controls.*

United Electric Controls COMPANY
85 SCHOOL STREET, WATERTOWN, MASS.

CIRCLE 34 ON READER-SERVICE CARD

X-Y Recorder

The new Model 670A X-Y recorder makes it possible to plot two rapidly changing variables such as velocity vs. acceleration of mechanical elements, transistor characteristics, and various other phenomena



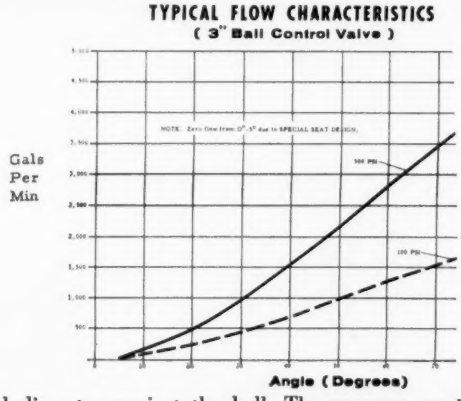
X-Y RECORDER OPTICAL SYSTEM

which are beyond the range of existing electromechanical X-Y recorders. Since the Model 670A employs optical galvanometers and a light beam to produce the recording trace, it can attain writing speeds greater than 2500 in/sec. and a frequency response flat to 100 cps. Basic sensitivity is 0.625 volt/inch . . . (*From new 2-page catalog sheet, Sanborn Co., Industrial Div., Waltham 54, Mass.*)

FOR THIS LITERATURE CIRCLE 177 ON READER-SERVICE CARD

High-Pressure Ball Valves and Venturi Shut-off Valves

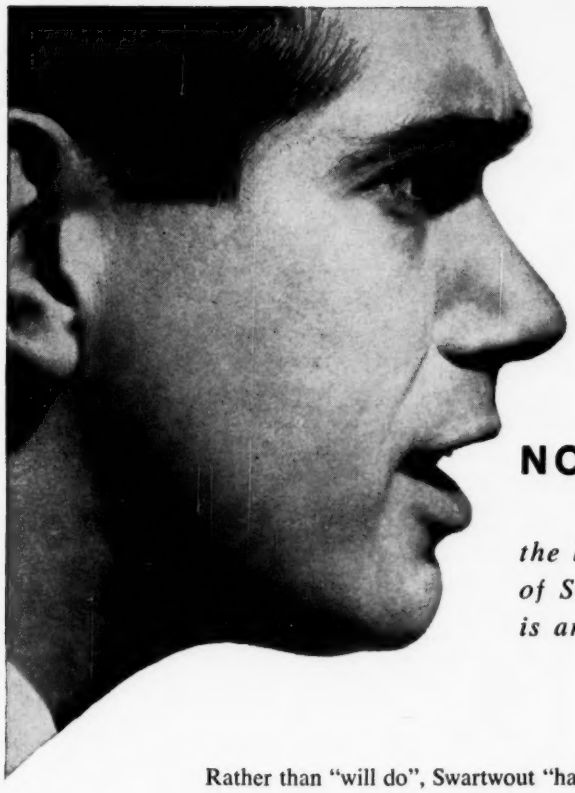
The 3″ ball valve assembly is designed to control the flow of liquids at 1500 psig from −65°F to +300°F with low pressure drops . . . The valve is designed to seal by means of the fluid pressure on the area between the O-ring seal diameter and the Teflon



seal diameter against the ball. The pressure on this small annular area holds the sleeve assembly against the ball . . . . Features include simplified in-line servicing; full open actuation in 250 milleseconds; capable of 50 cycles per second response . . . .

The Venturi Valve is a unique combination of a cavitating or non-cavitating venturi and a pilot operated shutoff valve . . . . (*From 2 new 4-page Publications PDS-5-2 and PDS-5-10, Components Dept., Thiokol Chemical Corp., Reaction Motors Div., Ford Rd., Denville, N. J.*)

FOR THIS LITERATURE CIRCLE 178 ON READER-SERVICE CARD



NO PROMISES NEEDED

the long-term reliability of Swartwout electronic control is an established fact

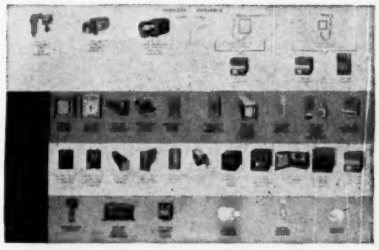
Rather than "will do", Swartwout "has done." No promises—instead, explicit facts based on demonstrated performance. Thousands of electronic control loops (some in service for almost a decade under every conceivable climatic condition) are your assurance when you use Swartwout equipment.

Design philosophy at Swartwout has focused on reliability. The choice of AC for the measuring circuit has permitted use of the simplest and most reliable electrical transmitter ever offered. It has also permitted more stable amplification techniques at the receiving instrument. Now, with the introduction of the new Thermo-Drive valve actuator, highest reliability can be characteristic of the entire loop, sensor through control actuator.

Facts, figures, names and places of installations are most impressive . . . and are available to any instrument user with a practical "show me" approach.

NEW BULLETIN . . .
SHOWS YOU IN PICTURES

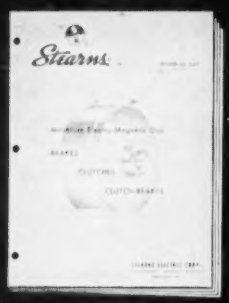
A new bulletin graphically relates electronic control equipment to practically all process variables. Request Bulletin A-913.
Swartwout Division, Crane Co., Hooksett Industrial Park, Manchester, N. H.



SWARTWOUT
DIVISION
CRANE CO.

. . . world leader in electronic process instrumentation

CIRCLE 35 ON READER-SERVICE CARD

NEW Stearns
BULLETIN
miniature
CLUTCHES...BRAKES

12 Pages of engineering data — dimensions — performance curves — weights — complete selection information. Request Bulletin 504-E

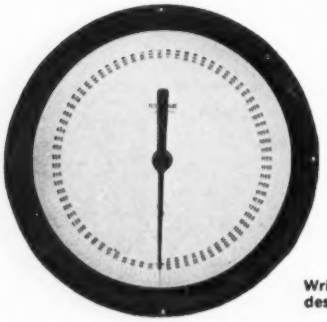
For superior Performance of ANY Machine...Specify Stearns!

Stearns ELECTRIC CORPORATION
120 North Broadway
Milwaukee 2, Wisconsin
Phone: BRoadway 2-1100

THE COMPLETE LINE OF CLUTCHES . . . BRAKES . . . CLUTCH-BRAKES

CIRCLE 36 ON READER-SERVICE CARD

PRECISION TEST GAUGES



Designed for the Ultimate in Accurate Pressure Measurement

Write for descriptive brochure M-28A

Consider These Advantages:

- 360° Calibration provides 25% greater scale length.
- Saves over 115 square inches of panel space.
- Ni-Span C Bourdon tube is temperature stable.
- Tube tip bleed is standard equipment.
- .15% full scale accuracy.
- Movement calibrated to dial, uniform increments.
- Capacities to 15,000 psi.

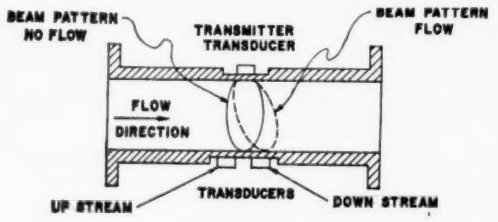
Write For Descriptive Bulletin AS 31

MARTIN DECKER
Martin-Decker Corporation
3431 Cherry Ave., Long Beach 7, Calif.
Precision Pressure Instruments— Testing — Weighing — Load and Force Measurement

CIRCLE 37 ON READER-SERVICE CARD

Ultrasonic Flowmeter

Various methods of measuring liquid flow with ultrasound have been tried in the past . . . The Gulton Ultrasonic Flowmeter utilizes an entirely different concept: the transmitter, a Glennite piezoelectric ceramic transducer, sends an ultrasonic beam of predetermined

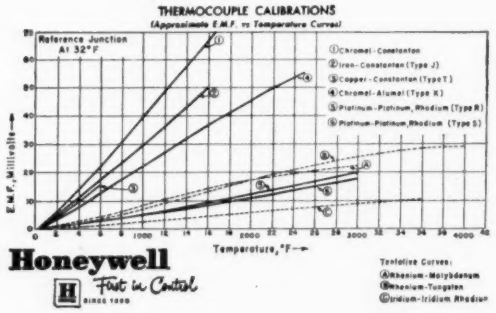


frequency across the stream and measures the deflection of the beam under the influence of the flowing liquid. The pulses are reflected back and forth inside the pipe for several cycles of reflection. After each reflection, the amplitude of the echo decreases until it disappears. The amplitude of the sonic pulse received at the receiving transducer is a direct function of the flow of the liquid, since movement of the liquid deflects the sonic beam . . . (*From new 2-page Bulletin S9, Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J.*)

FOR THIS LITERATURE CIRCLE 179 ON READER-SERVICE CARD

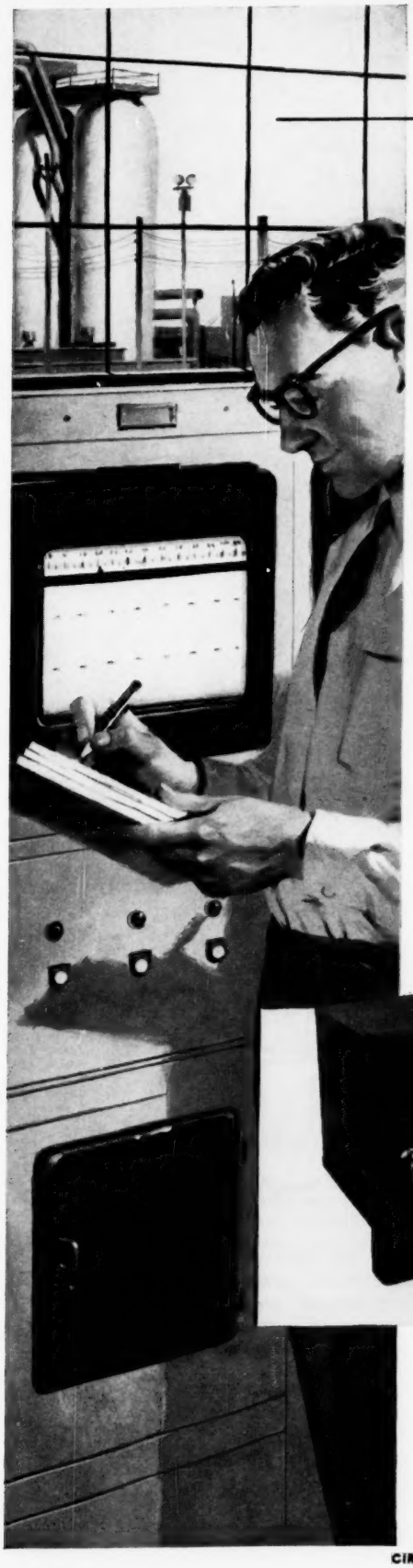
New Values for High-Temperature Thermocouples

Two relatively new types of thermocouples . . . rhodium-iridium/iridium and tungsten/rhenium—are useable above 3000°F, the maximum temperature which the most resistant of conventional thermo-



couples can withstand . . . The tungsten-rhenium thermocouple . . . is outstanding in stability and power for applications in other than oxidizing atmospheres up to 4000°F and potentially to temperatures approaching 5000°F, compared with the 2400°F limit for chromel-alumel thermocouples . . . (*From new 2-page news release Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Wayne & Windrim Ave., Phila. 44, Pa.*)

FOR THIS LITERATURE CIRCLE 180 ON READER-SERVICE CARD



DESIGNED FOR RELIABILITY THROUGH
WESTON "UNITIZED" CONSTRUCTION

PEAK PICKING RECORDER FOR GAS CHROMATOGRAPHY SPEEDS ANALYSIS... SIMPLIFIES PROCESS CONTROL

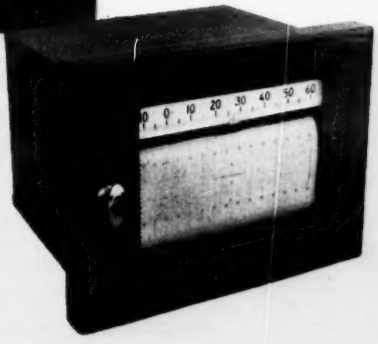
Weston Peak Picking Recorders are now serving the chemical and petroleum industries in critical applications for gas chromatography. They are also valuable for other uses where peak height is an important factor.

Simplified analysis is provided with the Model 6707 Recorder since only peak heights are indicated. Successively numbered points are printed on a *slowly* moving chart. Result: many hours of stream data are immediately available for study in the recorder window.

Extremely versatile, this multi-point instrument can handle as many control and transmission signals as there are stream components. And it is often used in conjunction with control systems, data loggers and computers. It can be fitted to protect against disappearing components and false peaks.

Other features include electronic peak detection; plug-in amplifier; easily replaceable range standards; and an exclusive D-PAK (T.M.) that eliminates standard cells, batteries, and standardizing mechanisms. The compact recorder is housed in a rugged, dust-resistant case which permits universal mounting—panel, wall or table.

Ask your local Weston representative for complete information on the Peak Picking Recorder and other instruments for industry, or write for Catalog 08-101. Weston Instruments Division, Daystrom, Inc., Newark 12, New Jersey. *International Sales Division, 100 Empire Street, Newark 12, New Jersey.*
In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ontario.



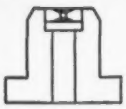
Available in 2, 10 or 20-second carriage speeds across full 10-inch scale. Points: 2, 3, 4, 6, 8, 12. Chart speeds: Multiple—1 to 24 inches per hour; Single—24 to 960 inches per hour. Operation: 115 volts, 60 cycles; or 115 volts, 50 cycles. Optional features include: alarm contacts, pen dragger, and time operation pen.

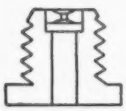
DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION

CIRCLE 38 ON READER-SERVICE CARD

PRECISION
JEWEL BEARING ASSEMBLIES . . .

for AIRCRAFT • ELECTRICAL
MECHANICAL and
MARINE
INSTRUMENTS





Sapphires set in brass, or other metal assemblies made in any quantity to close tolerance specifications are produced by Moser Jewel Company—*manufacturers of industrial jewels for over 50 years.*

Moser also provides highly polished pivots, staffs —silicon and spring loaded assemblies for high shock resistance.

SEND SPECIFICATIONS — DETAILED INFORMATION READILY GIVEN.

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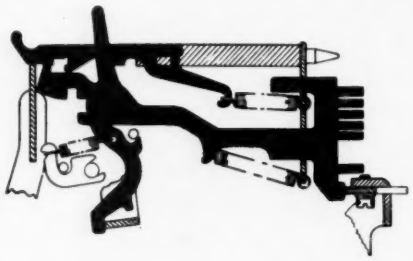
"Manufacturers of all types of Industrial Jewels"

CIRCLE 39 ON READER-SERVICE CARD

CHARTS
for Recording Instruments
We offer to the Instrument Maker Charts for all methods of Recording: Pen, Ball Point, Electrical, Thermal, Pressure and Metallic Stylus.
Uniform accuracy is assured through the use of specialized equipment operated under controlled atmospheric humidity conditions.
GUBELMAN
CHARTS INCORPORATED
100-6 E. KINNEY ST., NEWARK 5, N. J.

The Teletype Stunt Box

In the early days of printing telegraph, "stunts" was the term applied to nonprinting functions. These functions were actuated by function or "stunt" bars in the function assembly of printing telegraph equipment.

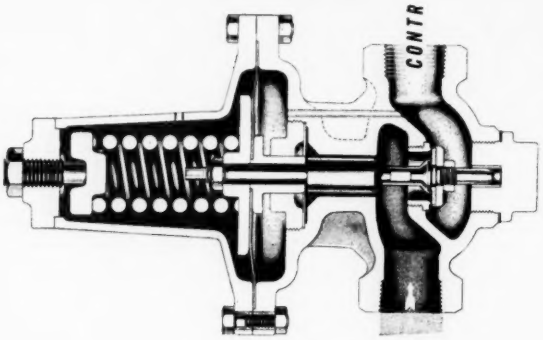


Early use of the term "stunts" has been carried forward to our present day designation of the function assembly as a "stunt box."

Basically, the stunt box will perform the following operations: (1) Mechanically initiate internal functions within the typing unit of the page printer set. (2) Electrically control functions within the page printer set. (3) Electrically control external equipment . . . . (*From new General Description 28 SB, Issue 1, Teletype Corp., 4100 Fullerton Ave., Chicago 39, Ill.*)

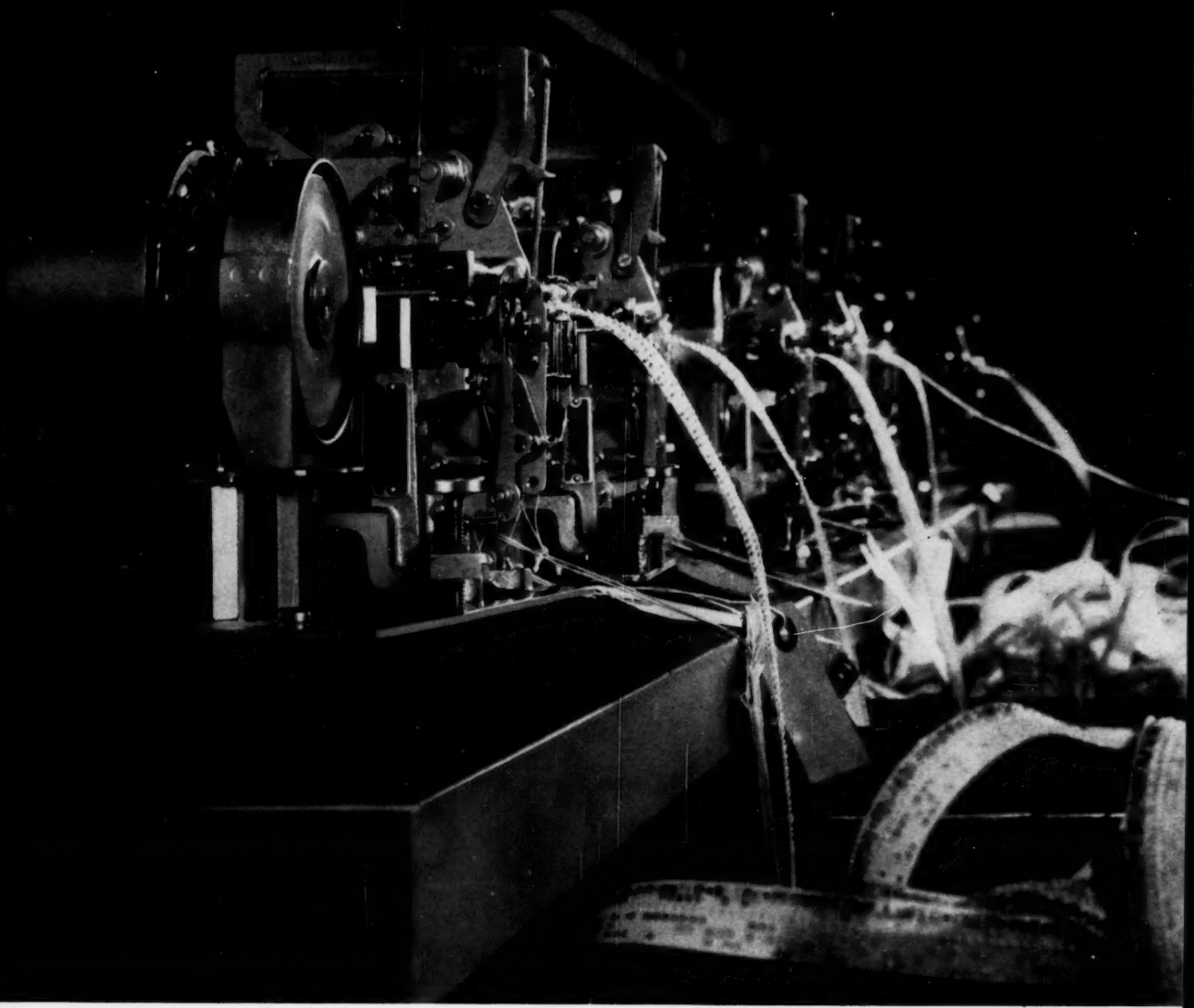
FOR THIS LITERATURE CIRCLE 181 ON READER-SERVICE CARD

Controlled Pressure Eliminates Water Waste



Inlet pressure acts upward on small balancing diaphragm to equalize downward pressure on valve disc, providing fully balanced action. Inlet pressure variations are equalized without affecting set point. When the adjusting spring is compressed, it opens the main valve to admit fluid to downstream side . . . When the downstream pressure under the large diaphragm equals the force exerted by the adjusting spring, equilibrium is restored and the main valve maintains flow of the set downstream pressure . . . (*From new 4-page Bulletin 553-A, Leslie Co., 507 Grant Ave., Lyndhurst, N. J.*)

FOR THIS LITERATURE CIRCLE 182 ON READER-SERVICE CARD



Continuous operation— a Teletype equipment tradition

All Teletype equipment . . . like the tape punches being final-tested above . . . are subjected to a rigorous quality-control program to insure that the units will give continuous, day-in, day-out performance in your service. Such performance is a Teletype tradition, established during more than fifty years of manufacturing data communications equipment.

To maintain this performance tradition requires much more than testing, however rigorous. It begins with the very design of the units themselves—the product of extensive research and development facilities, backed by cumulative experience. And it involves precision manufacture—employing the latest technological advances, from highly specialized machine tools and automated processes to electronic measuring and sensing devices.

When you select Teletype equipment to speed your communications and cut your paperwork costs, you can be sure of built-in quality. Teletype Corporation manufactures this equipment for the Bell System and others who require the utmost reliability from their data communications systems.

Typing Tape Punch

Tape Reader

Send-Receive Page Printer

Automatic Send-Receive Set

FREE Model 28 line folder. Write Dept. 27F, 4100 Fullerton Avenue., Chicago 39, Illinois

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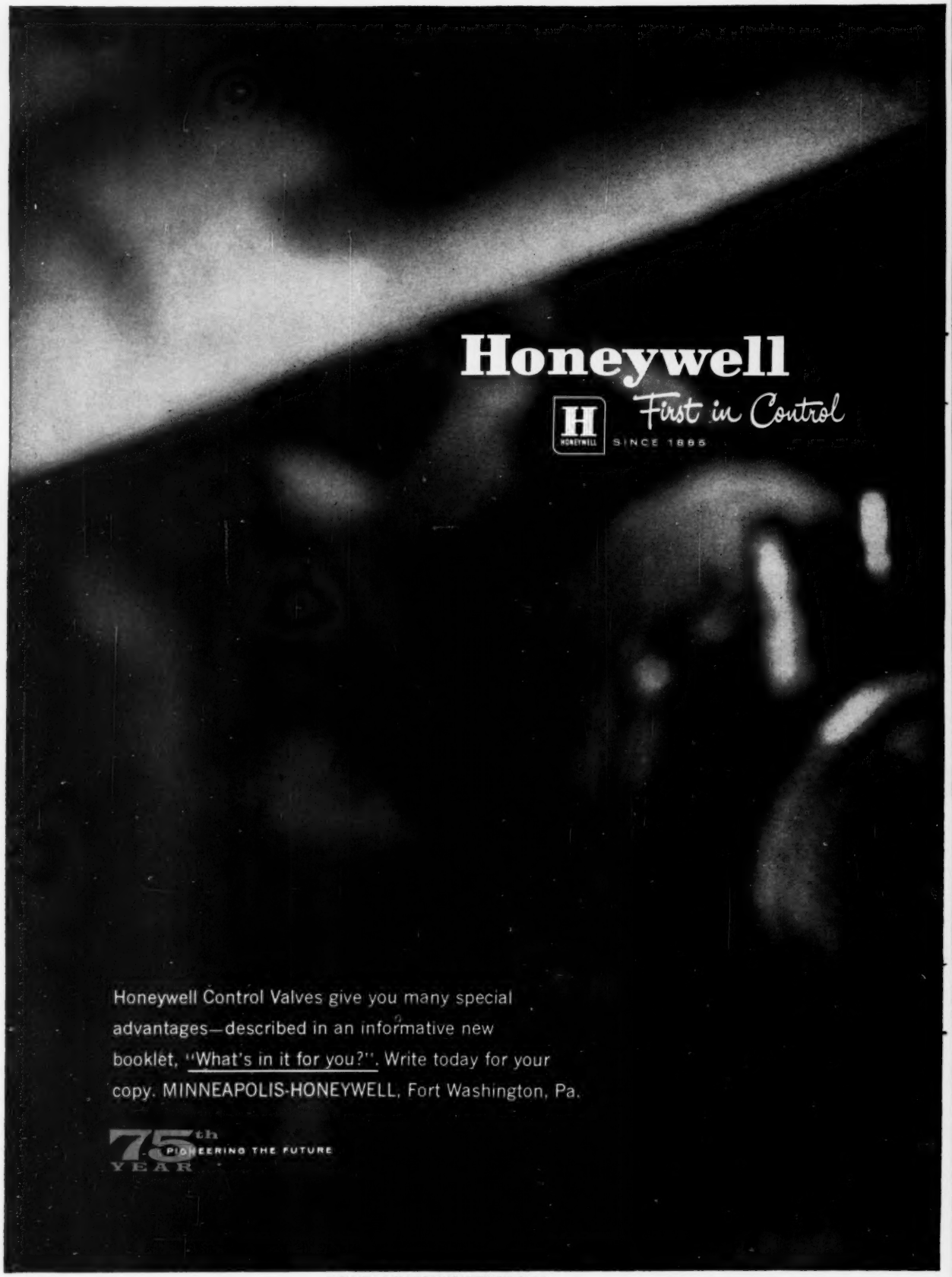
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

CIRCLE 40 ON READER-SERVICE CARD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First in Control
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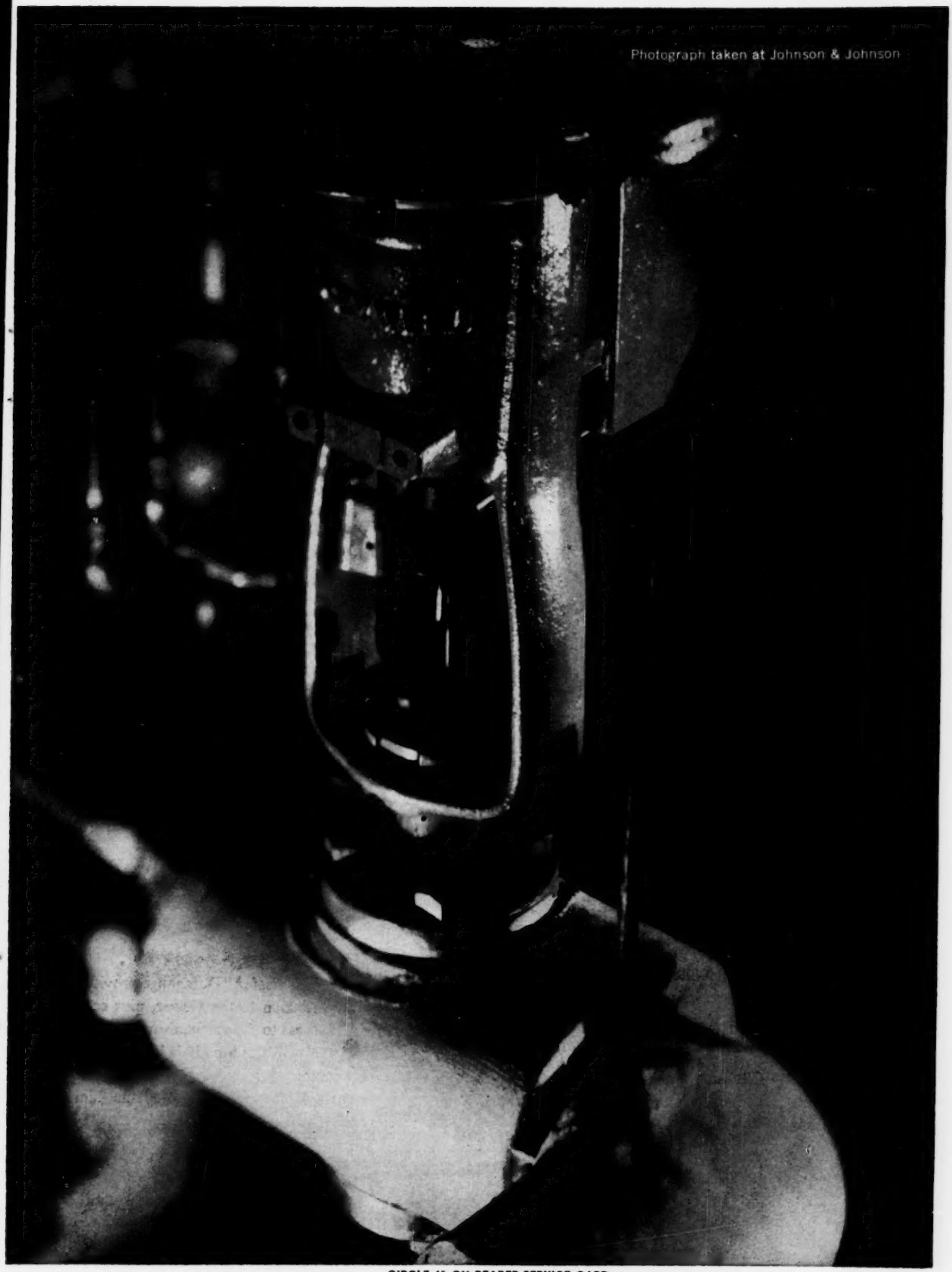
HONEYWELL
SINCE 1885
Honeywell Control Valves give you many special advantages—described in an informative new booklet, "What's in it for you?". Write today for your copy. MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.
75th YEAR
PIONEERING THE FUTURE

CIRCLE 41 ON READER-SERVICE CARD



CIRCLE 41 ON READER-SERVICE CARD

accuracy

ASHCROFT DURAGAUGES measure pressure with precise accuracy no matter how severe the conditions of service

Ashcroft Duragauges are available in pressure ranges from 15 psi (or vacuum) minimum to 100,000 psi. Dial sizes: 4½" through 12".

sustained

The Bourdon tube in Ashcroft Duragauges is manufactured to precision standards of flexibility and mono-linked to the rotary movement. When pressure flexes the tube, the gauge pointer is always positively positioned, because it is mounted on the geared center shaft of the movement. Sustained high accuracy and long life are assured.

Choose your Ashcroft Duragauges made of components best suited to your needs. Eight Bourdon tube materials are available. Movement of stainless steel with nylon bearings and pinion gear for longest wear. Case materials: special aluminum alloy or tough phenol plastic.

The unique "Maxisafe®" Duragauge provides absolute protection to the viewer, plus easy and quick access to the mechanism. Your industrial supply distributor will help you select the best combination of components for your Ashcroft Gauge requirements. Phone him today or write for Catalog 300B.

MAXWELL M&M MANNING & MOORE INC. TRADE MARK

ASHCROFT PRESSURE GAUGES

A product of

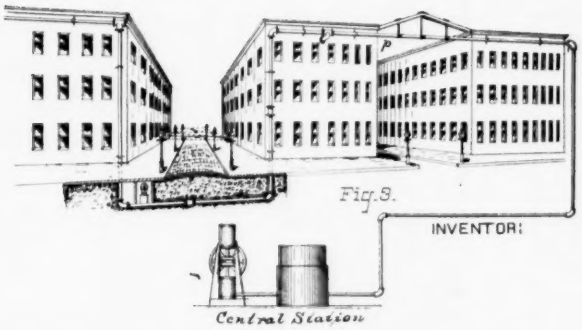
MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 42 ON READER-SERVICE CARD

PANHANDLE PETE

Pneumatic Electricity Generation



The various areas or buildings to be lighted have been supplied with electricity through wires charged by dynamo-electric generators run by steam engines located within the immediate area to be illuminated; or, central supply-stations have been established and the electric currents generated thereat on a large scale have been transmitted to the remote points, to produce the required light through main and branch conductors. In the first-named system the cost of skilled attendance to control the engines, the expense of water and fuel to run the engine, the valuable space required (when the system is used in crowded cities) for the engine, its boilers, water and coal supply, and its constantly-accumulating ashes and waste matter, and the added risk due to the presence of fire on the premises, together with the great outlay for equipment, make it impracticable. In the second-named system similar difficulties are encountered. Owing to the great loss experienced when currents of large quantity are sent to a great distance over ordinary conductors, it becomes necessary, if the electricity is to be supplied on a large scale, to use conductors of very great size, and therefore large cost, while, if it is attempted to use the system of electrical supply in which currents of great tension are employed serious difficulties are met with in the matter of properly insulating the conductors.

The object of my invention is to supply the streets, areas, blocks, or buildings of a city or town in a practicable manner with any desired quantity of electricity for the purposes of electrical illumination, plating, etc., avoiding the risk, inconvenience, and expense incident to other systems.

I accomplish these objects by the employment of compressed air conveyed in suitably-placed pipes and mains from a central or main compressing-station to combined air-motors and electric generators of suitable construction, arranged to supply a number of independent conducting-wires, each containing an electric light of any known form, all as will be more fully hereinafter set forth.

The employment of compressed air as a means of transmitting power to very long distances has been demonstrated to be practicable, and, as over other means, has the striking advantage that the energy observable at the point of conversion, even when placed miles away from the compressing-station, is but slightly less than that indicated at the source of supply. Whatever loss may occur is due only, when the pipes are properly constructed, to friction, and to the shrinkage of the air by cooling. The loss of pressure due to the last cause is wholly compensated for in my system by the passage of the air into the motor at a higher temperature.

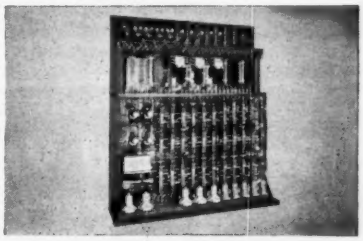
Although any of the ordinary air-engines or motors can be employed with dynamo-electrical generators belted or geared to them for supplying electric currents, I prefer to use a motor and dynamo-machine combined, as advantages are gained which will be more fully stated hereinafter.

Charles E. Buell
Patent 344,344
June 29, 1886

GULF
UNION CARBIDE
Kodak
Judging by the Company We Keep...
Electro-Mech

. . . "the Company We Keep" are keenly aware that high-density Pneumatic Control Circuits require manufacturing experience and know-how.

At the drawing-board level, the system must be laid out with complete understanding of ultimate field service demands.



At the shop-floor level, experienced technicians must employ the soundest procedures known to the craft.

—So that, in the end, a complex system is produced in its simplest, most functional form.

The *extra care* given to these matters assures "the Company We Keep" that *their* control systems reflect the best abilities of the industry.

Will you join this distinguished group by requesting an Electro-Mech quotation on your *next* requirement?

Electro-Mech Corp., Norwood, N. J.

Electro-Mech

CIRCLE 43 ON READER-SERVICE CARD

GREEN PANTOGRAPH ENGRAVERS

● ELIMINATE DELAYS!

● KEEP YOUR OPERATING COSTS WHERE THEY SHOULD BE!

PORTABLE 40-POUND BENCH MODEL 106

Here is a speedy, economical 2 or 3-dimensional engraver used by thousands of dollar-conscious companies. It features 5 positive, accurate pantographic ratios; ball bearing spindle with 3 speeds up to 14,000 rpm. Is supplied with one copy carrier that accepts all standard master type sizes. Will actually work up to 10" by any width. Height of pantograph and position of cutter are continuously adjustable.

You Make Your Own Engraved Nameplates!

MODEL D-2 HEAVY-DUTY 2-DIMENSIONAL

Pantograph for milling, drilling and engraving.

Vertical adjustment of copy table automatic with Pantograph. Features: unobstructed on 3 sides to take large work; micrometer adjustment for depth of cut; ball bearing construction throughout; spindle speeds up to 26,000 rpm for engraving or machining; vertical range over 10"; ratios 2 to 1 to infinity — master copy area 26" x 10"

NEW MODEL D2-201 PNEUMATIC ATTACHMENT

for use with Model D2 Pantograph Engraver to rapidly drill holes in printed circuits by tracing templates. Drills as many as 100 holes per minute. Equipped with foot switch; spindle air cylinder; regulating valve and pressure gauge; filter and oiler. It's ready to use as soon as it's attached to an air compressor

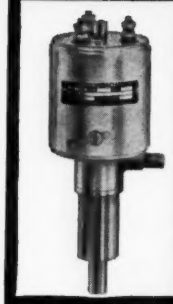
Write or call for full details and prices.

GREEN INSTRUMENT COMPANY, INC.
Dept. 86, 295 Vassar St.
Cambridge 39, Mass. Tel. ELiot 4-2989

CIRCLE 44 ON READER-SERVICE CARD

SPEED SENSITIVE SWITCH GOVERNORS

Adjustable within a speed range while running



1 Switch UNDERSPEED OR OVERSPEED

2 Switches UNDERSPEED AND OVERSPEED

3 Switches UNDERSPEED, INTERMEDIATE AND OVERSPEED

All "STANDARD" Speed Sensitive Switches can be furnished to TRIP at any speed between 300 and 6000 RPM. On special order higher or lower speed operation can be supplied. Also special body styles, mounting pads, drives, terminal connectors and caps are available.

Write for Bulletin 504 for further information

SYNCHRO-START PRODUCTS
Since 1932
8151 NORTH RIDGEWAY AVENUE • SKOKIE, ILLINOIS

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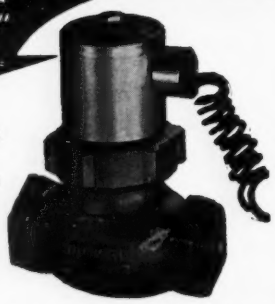
TYPE M

Solenoid Valves

"We've actually improved quality and radically lowered prices. Compare!"



TYPICAL USER NET PRICES F.O.B. FACTORY

SIZE	1 to 5	100 to 499
½"	$15.40	$11.15
¾"	18.50	13.60
1"	24.25	18.50
1½"	48.00	42.40

PRESSURES TO 400 psi

Packless • 2-Way • General Service • Normally Closed

Sizes ⅜" to 3" • Temperatures to 250° • Molded epoxy resin waterproof coils • Unbreakable piston rings • Self-cleaning • Guided valve seats • Simple, rugged construction. Only 2 moving parts • No diaphragms or linkages • Cushioned closing. No damaging hammer • Easy-off "O" ring bonnet construction in sizes ⅜" thru ¾" • High temperature coils and explosion proof housings at slight extra cost. Immediate delivery. Ask for Bulletin 600-M.

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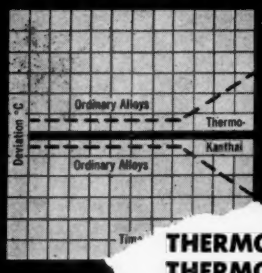
INDIANAPOLIS 18, IND.

GOULD SOLENOID VALVES VELVETROL

CIRCLE 45 ON READER-SERVICE CARD



there are many reasons why!

THERMO-KANTHAL THERMOCOUPLES ARE MORE STABLE

Thermo-Kanthal is a product of world recognized Kanthal leadership in special purpose resistance and heating alloys. It is specifically designed to combat the problem of stability with age and use. Particular attention to the composition of the negative leg has resulted in a new order of accuracy and stability, particularly in the 1800°F to 2300°F range.

Thermo-Kanthal couples meet all standard emf curves. No change in instrumentation is necessary. In addition to operating savings, as in less recalibration, Thermo-Kanthal actually costs less initially. Write for data today.

KANTHAL

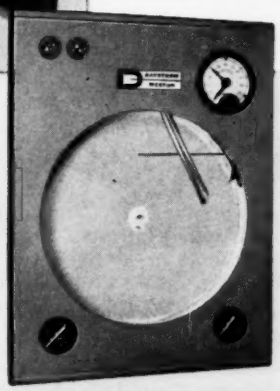
THE KANTHAL CORPORATION
17 Amelia Pl., Stamford, Conn.
Can. Rep., Ferro Enamels, Ont., Can.

CIRCLE 47 ON READER-SERVICE CARD

DESIGNED FOR RELIABILITY THROUGH
WESTON "UNITIZED" CONSTRUCTION

COMPACT WESTON RECORDER CONTROLS TEMPERATURE OR PRESSURE ...PRECISELY...AUTOMATICALLY

The Weston Elapsed Time Controller is especially designed for batch type operations where precise timing is an important process factor. It provides interchangeability of temperature and pressure systems, and covers the complete range of Bourdon tube type instruments. All classes of thermal systems are available to suit the individual applications.
Model 7003 is activated by an external button, stops after preset interval, and automatically resets for the repeat cycle. A large-capacity pen operates with a minimum of pressure, assuring clear, sharp records on a 12" chart.
The unit is housed in a dust and moisture-proof case which is conveniently designed for panel or wall mounting.
All internal components are mounted on the baseplate, and are integrated in a simple design for maximum efficiency and sustained accuracy.
Ask your local Weston representative for complete information on this and other Weston instruments for industry, or write for Catalog 08-705, Weston Instruments Division, Daystrom, Incorporated, Newark 12, N. J.
International Sales Division, 100 Empire St., Newark 12, N. J.
In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ont.



Operation: 115 volts, 60 cycles. Time ranges: 1, 5, 12 or 24 hours. Minimum timer setting 4% of timer range. Pneumatic Control – 2-50% proportional band. SAMA standard electric chart drive. Rugged bridge-type pen arm suspension. 4.75" pen travel.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION

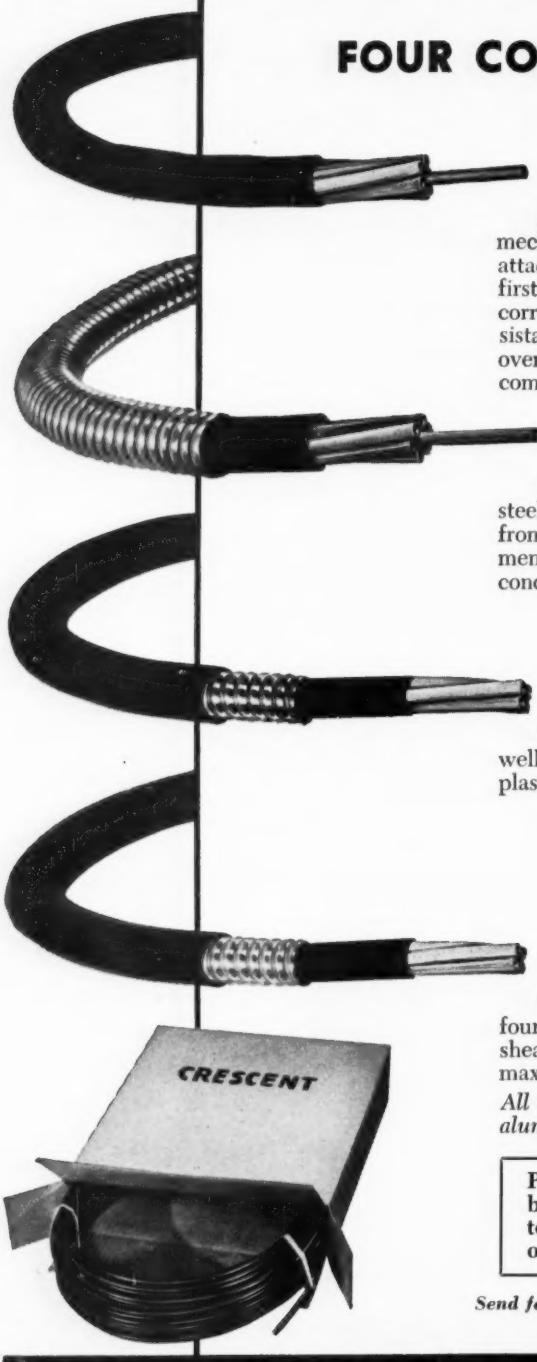
CIRCLE 48 ON READER-SERVICE CARD

The Answer to Your Corrosion Problems

CRESCENT ARMORED MULTITUBE*

*Reg. Trade Mark

FOUR CORROSION-RESISTANT TYPES



TYPE CT

In damp or corrosive locations where a moderate degree of mechanical protection to the tubes is required, as in troughs or attached to sheltered building surfaces as supporting means, the first construction illustrated is recommended. It employs a tough, corrosion-resistant polyvinyl chloride thermoplastic sheath, resistant to water, acids, alkalies, oils and most chemicals, applied over CABLED copper tubes. The sheath will not support combustion.

TYPE CTA

Gives corrosion protection to the tubes, and the galvanized steel armor protects the tubes and polyvinyl thermoplastic sheath from mechanical injury during and after installation. Recommended for direct burial in concrete or pulling into underground conduits.

TYPE CAT

Gives corrosion protection to the galvanized steel armor as well as the tubing. Recommended where the polyvinyl thermoplastic sheath will not be subject to mechanical injury.

TYPE CTAT

Combining the advantages of Types CTA and CAT, the fourth type illustrated has the polyvinyl chloride thermoplastic sheath both under the armor and over the armor, thus providing maximum mechanical and corrosion protection.

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BOOKS

Radiation Counters and Detectors, by C. C. H. Washtell [c1958], Philosophical Library, Inc., 15 East 40th St., New York 16, N. Y., 115 pp., 8½", clothbound $7.50. Written by a British expert, the book is an introduction to the subject for those possessing a general scientific education, and perhaps for the first time faced with the use of counting devices.

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Engineering Data Processing System Design, by Arthur D. Even, [c1960] D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J., 282 pp., 9", clothbound $6.50. The author delineates mechanization possibilities of an engineering department by use of microfilms and punched cards prior to efficient conversion to an electronic data processing system. An actual installation is thoroughly described.

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Thermodynamic Principles for Chemical Engineers, by Roger Gilmont, [c1959] Prentice Hall, Inc., Englewood Cliffs, N. J., 339 pp., 9", clothbound $11.00. Thermodynamics are approached by graphical methods of calculation while mathematics are employed only up to and including differential equations.

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An Introduction to Statistical Communication Theory, by David Middleton, [c1960] McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y., 1140 pp., 9", clothbound $25.00. This comprehensive work in the International Series in Pure and Applied Physics describes general methods and a philosophy which apply to all areas of communication science, although electronic and electrical systems, naturally, are treated with preference.

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Master Receiving-Picture-Tube Substitution Guide Book, by H. A. Middleton, [c1949] John F. Rider Publisher, Inc., 116 West 14th St., New York 11, N. Y., 343 pp., 11", paperbound $7.45. This book contains all of the substitutions of receiving and picture tubes available anywhere, including American to European and vice versa.

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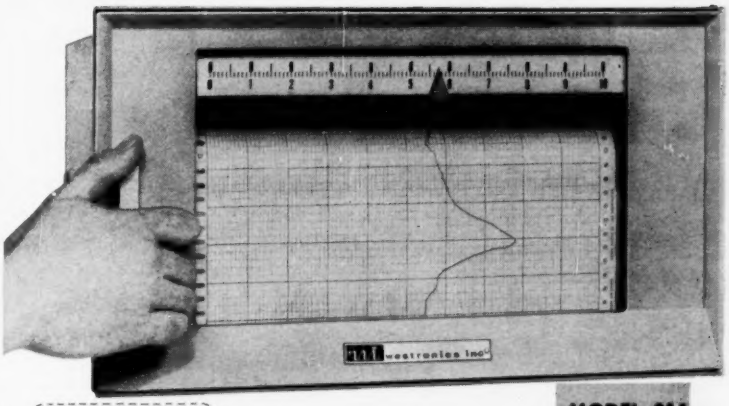

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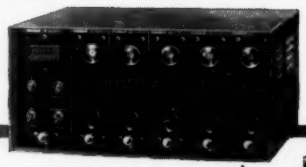

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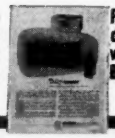

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Tubexperience in action

MEMORANDUM
FROM THE ENGINEERING DEPARTMENT
Joe—
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Frank

Brown Instruments, Industrial Division of Minneapolis-Honeywell Regulator Company, a leading manufacturer of indicating, recording and controlling instruments, recognizes the advantages of long lengths of capillary tubing.

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Superior has spent years in the development of manufacturing processes and quality control procedures for the production of close tolerance tubing. ODs range up to 3/16 in., IDs from .004 through .040 in. Analyses include Types 304, 316, 321, 347 and 446 stainless; also Monel, Inconel, nickel and carbon steel alloys. Data Memorandum No. 11 gives complete details —let us send you a copy. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

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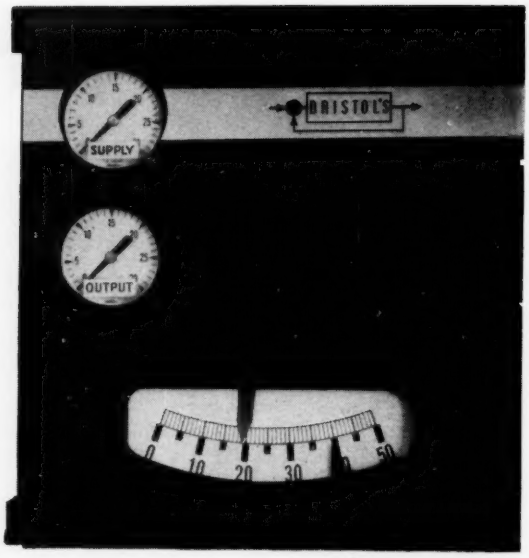

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RESET: 0.1 to 50 repeats per minute.

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PILOT CAPACITY: 4.0 scfm.

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MATERIAL: Aluminum housing; 316 stainless steel internal parts; Ni-Span C feedback element.

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CIRCLE 56 ON READER-SERVICE CARD

WJCC-ISA-NTC

The West Coast was the place for an editor in May, what with the Western Joint Computer Conference (San Francisco, May 3-5), the Summer ISA Conference and Exhibit (San Francisco, May 9-12) and the National Telemetering Conference (Santa Monica, May 23-25).

The Western Joint Computer Conference was particularly well attended, and a word must be said about the city of San Francisco, considered by many world travelers to be the most beautiful city in existance. Its combination of cosmopolitan nature, gracious inhabitants and scenic beauty is indeed unique.

The Western (and Eastern) Joint Computer Conferences, sponsored by the Institute of Radio Engineers, the American Institute of Electrical Engineers and the Association for Computing Machinery, have become the leading computer events of the year in terms of both exhibits and technical sessions. In the past the emphasis was almost entirely on digital computers, reflecting not only the greater size of the digital computer market (the tape handler market—a digital computer accessory—alone exceeds the entire market for analog computers) but also the feeling among digital-computer men that the analog computer would not share proportionally in the growth of the computer field.

Thus the participation of the National Simulation Councils in the WJCC, with three full technical sessions comprising nine technical papers, was an event of more than usual significance. This boost for the field of analog computers and simulation was the result largely of the persistent efforts of Jack Sherman (Lockheed Missile & Space Div., Sunnyvale), acting for the Simulation Councils, Inc. The result was a better balanced exhibit and conference, to the benefit of both analog and digital techniques. The analog papers (23% of the total) added depth and power to the technical program, as did the exhibits of the Beckman EASE computer, the Computer Systems new DYSTAC, and the Electronic Associates PACE analog computers.

JACK SHERMAN of Lockheed Missile & Space Division, Sunnyvale, Calif.

The increasing trend to combined analog-digital systems also was obvious. The technical papers included several on combined analog-digital techniques; the analog papers had much emphasis on repetitive operation and "digital" techniques for sampling, holding, slicing, etc.

The computer field is a dynamic one, and new products emerge as from a cornucopia. For example, the General Precision (Librascope and Royal-McBee) exhibit had data on no less than *ten* new computers, including the LGP-30, Libratrols 2000, 1000 and 500, RPC-4000, RPC-9000, CP-209 (bombing and navigation), etc.

Stromberg-Carlson exhibited the exciting S-C-4000-series high-speed printers, including one that can plot graphs at 15,000 points/second.

Autonetics (Division of North American Aviation) exhibited the small but powerful RECOMP computer (4096-word disc memory) and demonstrated RAFT (RECOMP ALGEBRAIC FORMULA TRANSLATOR) that makes it possible for an engineer without a computer background to operate the computer. Another small powerful computer that attracted great attention was the Packard-Bell pb 250, featuring add-subtract time of 12 usec, 46 commands, magnetostrative delay-line memory of 1808 words, and a $30,000 price.

Ampex unveiled two new digital tape handlers plus the exciting Wideband Magnetic Systems, using "Videotape" technique for recording 4-megacycle data. This is big data news. Where is tape going? Everywhere. For example, in addressing mass-circulation magazines (*TIME, LIFE, FORTUNE,* and *SPORTS ILLUSTRATED*) 40,000,000 address cards soon will be replaced by 130 reels of tape.

Bendix unveiled both the new G-20 large-scale core-memory data processing system, and an exciting high-speed graph plotter for use with the G-15, featuring step motors which move in 0.01" increments on each axis.

Disk memories were exhibited by both Autonetics and Laboratory for Electronics. The LFE Bernoulli Disk principle is unique in size and cost.

Not all the new products were in the main dis-

play area at the Jack Tar Hotel. Midwestern permitted select visitors to get an advance peek at the exciting M3000 digital tape transport (in a room at the Jack Tar) which features an electropneumatic tape-handling system with no rollers or capstans; air does all the work. Another feature is no programming restrictions up to highest tape speed. And in another room at another hotel, the invited visitor could see the interesting PERFOGRAPH of Advanced Instrument Corporation, featuring coded punched tape in which tiny holes are punched by electricity. Advinco also had an interesting new precise hygrometer (XEROMETER, which uses the expansion of a natural vegetable fiber to measure the moisture content of gases, liquids or solids, with a sensitivity of parts per million.

The Xerometer, of course, is an instrument, not a computer, and this leads us to the Summer ISA Conference and Exhibit, also held in San Francisco. The emphasis here was on analytical techniques, particularly chromatography. For example, Consolidated Electrodynamics Corporation selected its process control chromatograph from its line of many instruments to feature at the show, and other analytical instruments were exhibited by Mine Safety Appliances, Hays Corp., Hallikainen, Barber-Colman, Johnson-Williams and Beckman.

Products of special interest displayed at the ISA show included (1) new controlled-volume pumps by Wallace & Tiernan, (2) ball valves by Hydromatics, (3) high-sensitivity scopes and strain gages by Tektronix, (4) radiation pyrometers and thermometers by Bristol and Radiation Electronics, (5) pneumatic components for analog computation by Moore Products.

The relatively small attendance at this show probably reflected the large number of annual instrument shows, and it is unfortunate that the many fine papers presented will not be published anywhere except in small-circulation Proceedings. The field of instrumentation today is suffering from lack of publication of its many fine papers presented at its technical conferences, particularly since the *ISA Journal* now publishes commercial trade-journal-type articles rather than the technical papers of the field. This situation is a serious one for the field because the single greatest service to professionalism that a society offers is publication of the field's technical papers in its society journal. The instrument field is not being served this way at this time, and suffers from the lack of a professional-level society publication.

MHA

Technical Communications

TECHNICAL COMMUNICATIONS refer to "getting the idea across." It consists of two basic problems—first, the *physical* problem of acquainting a worker in one location of the work of another worker in another location and, second, the *educational* problem of making the work of the latter understandable to the former. Much effort is being devoted to the physical problem, very little to the educational.

The Physical Problem

The channels of communication have been expanded so greatly by publishers, technical societies, and public-relations and advertising firms that no technical development, however minor, remains unknown or unappreciated for days, if not hours. Dozens of trade journals, house organs, and company-routed publications flow across the engineer's desk every day. The sheer mass of news is such that he cannot hope to even scan more than a fraction of the material.

Thus the problem of abstracting and indexing published technical material has burst upon the technical community, and activity is increasing in machine indexing, machine abstracting, character recognition, machine search, etc., etc. One phase of this activity is centered about the Center for Documentation & Communication Research, School of Library Science, Western Reserve University, Cleveland, Ohio, where projects include:

Preparation of abstracts or glossaries
Encoding of abstracts or original material
Machine search of abstracts
Machine recognition of words

Each of these activities is underway on many fronts. For example, encoding and machine searching involves work on an international language for machine searching and translation. More than 300 abstracting and indexing services have been reported, mostly independent and uncoordinated, however. Many technical societies have phases of the abstracting work underway—The American Society for Metals is abstracting the world's metallurgical literature; the American Chemical Society indexes 100,000 articles a year in chemical literature; etc.

The National Research Council, the National Science Foundation and the Killian Science Advisory Committee all have indicated interest in this field of machine researching, and a fire has been built under the question of a need for a national information system by the Soviet All-Union Institute of Scientific and Technical Information (VINITI) in Moscow. This vast enterprise, with a staff of more than 2000, acquires, analyzes, abstracts and disseminates technical information in the world's literature for the benefit of Soviet technical workers. (Possible clue to Russian success—Russian abstractors receive five times as much pay as American professional abstractors.) Despite the excessive American obsession against centralized activity by the government, the Russian success has led the National Academy of Science to establish a documentation program.

A partial list of the activities in the field of "machine research" includes (1) ten books published by Interscience Publishers and Reinhold Publishing Corp., (2) more than 100 papers and reports from the Western Reserve University Center alone, (3) a 5-year program by the American Society for Metals to test the feasibility of mechanized searching in the field of metallurgy, (4) a conference on Practical Utilization of Recorded Knowledge, attended by 600 persons, Jan. 16-19, 1956; (5) a conference of Information Systems in Documentation, attended by 900, April 15-17, 1957; (6) an international conference on machine searching and translation, Sept. 6-12, 1959, with 75 papers from 10 countries; (7) a program at the National Bureau of Standards, which has developed a microfilm selection device and computer routines applicable to experimental machine search.

The Education Problem

All this indicates the extent of activity of the physical (mechanical and machine) approach to technical communications—but far, far less attention is being given to the education approach. The printed technical paper will indeed be delivered into the hands of the worker—but only scant attention is paid to the fact that he already receives more material than he can read, and that what he does read is too often not understandable.

This problem is the reason why much is heard of technical writing courses and articles and societies. But even within these activities there is little recognition that the problem is not mechanical or grammatical. Rather, it is a problem of level and perspective and overlapping frame of reference, permitting the reader to know why the author is proceeding along certain paths. This is basically a *technical editing* problem that is only now becoming dimly understood. As more and more persons realize that others, as well as themselves, can't understand that article or that book, the pressure will grow for published material than *can* be understood. Editors might even begin to read the manuscripts they now "edit." MHA

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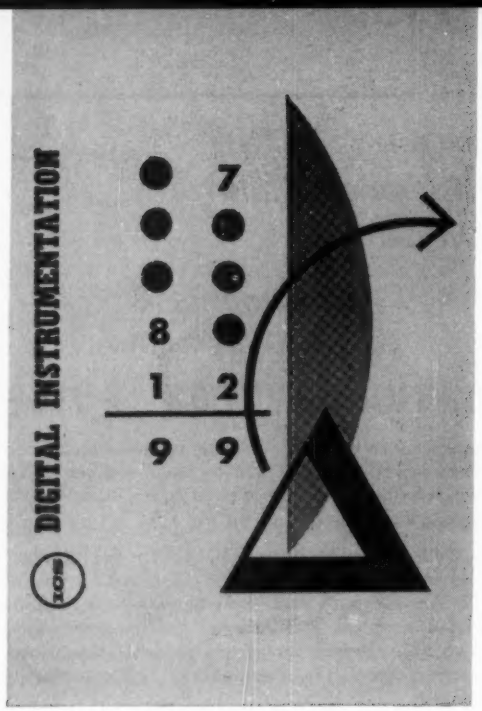

RING CODES

ROBERT W. BROOKS
Computer Control Co.

A ring code is a type of pattern generator which repeats a sequence of multibit numbers. It provides a means of dividing pulse frequency and performing synchronous logic.

A RING CODE is a code that repeats combinations of the bits in the code. For example, a 3-bit code has 8 possible combinations and is called an 8-place ring code (Fig. 1). The code runs through the eight combinations, over and over.

The word "ring" is derived from the way the code can be illustrated (Fig. 1,A). Any three adjacent bits in the ring can be enclosed by a bracket and comprise a possible combination. Once three adjacent bits have been selected as a starting place, then the bracket is shifted one bit clockwise for the next combination, etc. The bracket always includes three bits (A, B, C) reading clockwise. In Fig. 1,A start with the combination A = B = C = 0; this is enclosed in bracket one and is the first input to the ring-code package.

The package must then produce the output A = 0, B = 0, C = 1; this is the combination enclosed in bracket two. The package must accept this first-cycle output as the second-cycle input and then produce the output A = 0, B = 1, C = 1, etc, around the ring.

Another way of writing this ring code is shown in Fig. 1, B. Again, any three adjacent digits comprise a possible combination. Once the first combination is selected, the next is found by shifting the bracket one digit to the right. The ring code repeats without end.

This progression can be shown in the more-conventional truth table (Table 1). The A, B, C inputs for each cycle are shown. After the eighth cycle, the sequence is repeated. Note that the output from cycle one is the input for cycle two, etc.

An important characteristic of such a cyclic shift is that the B input of any cycle is the same as the C input of the preceding cycle. Likewise the A input of any cycle is the same as the B input of the previous cycle. Instrumentation can provide this progression by a delay line that produces B one cycle after C, and produces A one cycle after B.

Fig. 2 is the logic chart for this ring code. The eight squares include all possible combinations of the three inputs, A, B and C. The input of the first cycle is A = B = C = 0 and this square is number one. Square number two shows the input combination for the second cycle, etc. (see Table 1).

The output of each cycle must be the appropriate input of the next cycle, wherein the new A is the

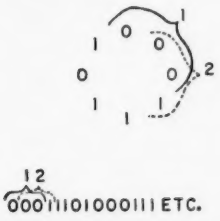

FIG. 1. TOP SHOWS an 8-place, 3-bit ring code that is read clockwise. There are eight possible combinations of the three-bit code. Bottom shows the ring code written in a straight line.

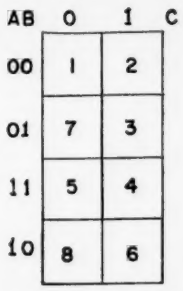

FIG. 2. NUMBER in each square of this logic chart identifies the cycle requiring that input combination of A, B and C.

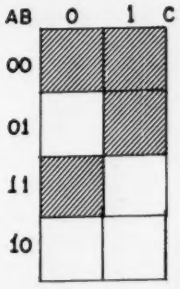

FIG. 3. LOGIC CHART with shaded squares showing which combinations must produce an output —to be used as C bit in next cycle.

TABLE 1—RING CODE TRUTH TABLE

Cycle	Input A	B	C	Output A	B	C
1	0	0	0	0	0	1
2	0	0	1	0	1	1
3	0	1	1	1	1	1
4	1	1	1	1	1	0
5	1	1	0	1	0	1
6	1	0	1	0	1	0
7	0	1	0	1	0	0
8	1	0	0	0	0	0
1	0	0	0	0	0	1
etc.						

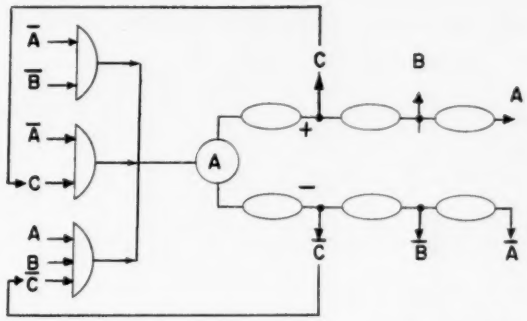

FIG. 4. THREE AND gates and several one-pulse-period delays connected as shown will implement the logic chart of Fig. 3.

previous B, and the new B is the previous C. Once a bit appears at C it subsequently marches to B, then A. Thus the C bit controls the progression of the code.

The package should produce an output whenever there is a C bit required in the input of the next cycle. Fig. 3 is a logic chart with shaded squares showing those combinations that must produce an output bit; this output bit becomes the C-bit input of the next cycle. There is a C bit required in the input of cycle two. Therefore, cycle one (A=B=C=0) must produce an output bit, and the square numbered one in Fig. 2 is shaded in Fig. 3. Since C = 1 in squares 2, 3, 4 and 6, we shade squares 1, 2, 3 and 5 in Fig. 3. That is, conditions 1, 2, 3, and 5 must produce a C pulse.

The logic chart of Fig. 3 is shown implemented in Fig. 4. As described in earlier installments an AND gate can implement a shaded square if its input legs are the conditions of that square. Also adjacent shaded squares can be implemented as a group. Thus the top gate in Fig. 4 provides an output whenever both A AND B are zero, regardless of C. This represents the top two shaded squares of Fig. 3. The next gate provides an output whenever A = 0 AND C = 1, regardless of B. This implements the top right square and the square just below it (Fig. 3). One more gate is needed to implement the input conditions for square five.

The (C) output is fed back and becomes the C input for the next cycle. The C output also is delayed one pulse period (ellipse symbol in Fig. 4) to provide B. B is delayed to provide A. Each output is fed back to the appropriate input leg, as is shown for C.

A ring code has many uses in synchronous logic. One use is to divide down a pulse repetition rate by some factor, such as 8. Any one of the eight unique combinations can be selected by a diode gate. Any one combination will appear every eighth period. Therefore, the pulse from an AND gate wired to accept only one possible combination will be of one-eighth the frequency of the source.

Such a gate could accept, say A=1, B=0, C=0. This is the input of cycle eight; this particular combination will appear once every eight cycles. The output of such a gate will divide the original pulse frequency by eight.

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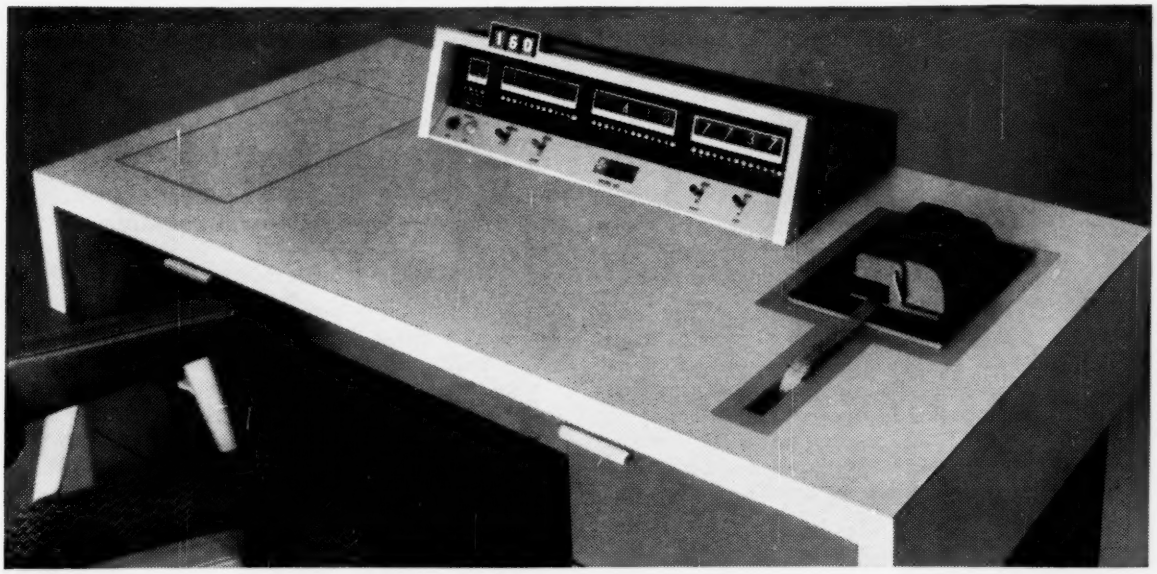

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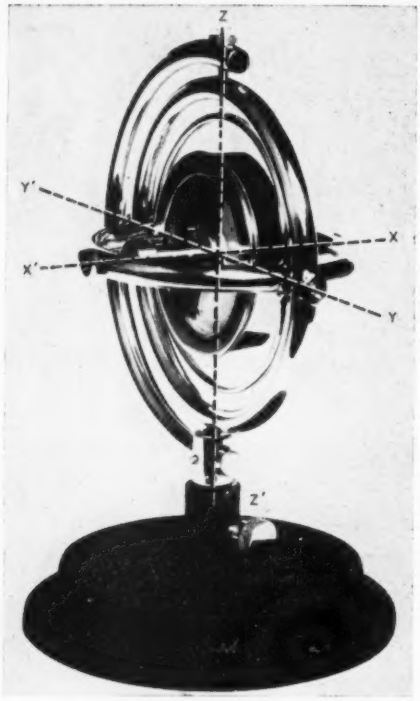


THE GYROSCOPE

MILTON H. ARONSON

The gyro has two useful properties—gyroscopic inertia (rigidity of plane) and precession. The latter has uses in instrumentation.

A GYROSCOPE is a rapidly spinning body that is free to rotate about three mutually perpendicular axes, so that its axis of rotation can assume any direction in space. It has two properties that make it useful in many ways including (1) stabilization, (2) bearing indication, (3) integration, (4) torque and force measurement, etc. These properties are *gyroscopic inertia* and *precession*.

Gyroscopic Inertia

A perfect gyroscope is unweighted, perfectly balanced, and frictionless. Fig. 1 shows a free gyroscope and its three axes. The rotating wheel rotates about the axis of rotation (axis X-X′ in Fig. 1). If the rotor is made to rotate rapidly, the plane of the rotor remains parallel to its original position no matter how the support of the outer gimbal ring moves. This property of the gyroscope is called gyroscopic inertia or rigidity of plane, referring to the apparent rigidity of the plane of the rotor.

This property results from the elementary physical principle that a body tends to continue unchanged in momentum (Newton's Second Law). Angular momentum is $I\omega$, where I is movement of inertia of mass, ω is angular velocity. When the spinning wheel (of high moment of inertia) is given a high angular velocity, the angular momentum is very high (of same order of magnitude as a moving locomotive engine or a bullet emerging from a rifle). Thus, according to Newton's Second Law, the plane of the rotor remains "stationary" even though its base is moved.

The free gyro is stable and rigid with respect to outer space, not with respect to the earth. Thus, as the earth rotates once in 24 hours, the axis of rotation of the gyro appears to complete a revolution of motion and to come back to its original position. Fig. 2 illustrates how a free gyro would look if it were located at the equator, pointed in an east-west direction, and seen from a point in space on the axis of the earth. Six hours later the building in which the gyroscope is running appears to the observer in space as shown in Fig. 2B (whereas the axis of the gyroscope actually points in the original direction because of gyroscopic inertia.) Twelve hours later the relative position of the gyroscope and building appears as in Fig. 2C. To the earthbound observer inside the building, however, the axis of the gyroscope appears to rotate in a vertical plane through 360° in 24 hours.

If the gyroscope were located at a geographic pole and if its axis of rotation were in a level position, it would appear to the earthbound observer at the pole to rotate in a horizontal plane through 360° in 24 hours. At latitudes other than the equator and the poles, the gyroscope describes a combination of the two motions—that is, it appears to turn in both a horizontal and vertical plane simultaneously, so that it both tilts and turns depending on its starting orientation with respect to the axis of the earth. It is interesting to note that if the free gyroscope is located on the equator, and if its axis of rotation is directly on a meridian, then the axis of rotation is parallel to the axis of the earth, and the plane of the rotor remains stationary in a vertical plane without apparent motion of any kind.

To the observer on earth the free gyroscope does *not* appear to have good long-time (hour-to-hour) stability. However, although the long-time stability (with respect to the earth) is reduced because of the rotation of the earth, the same phenomenon is

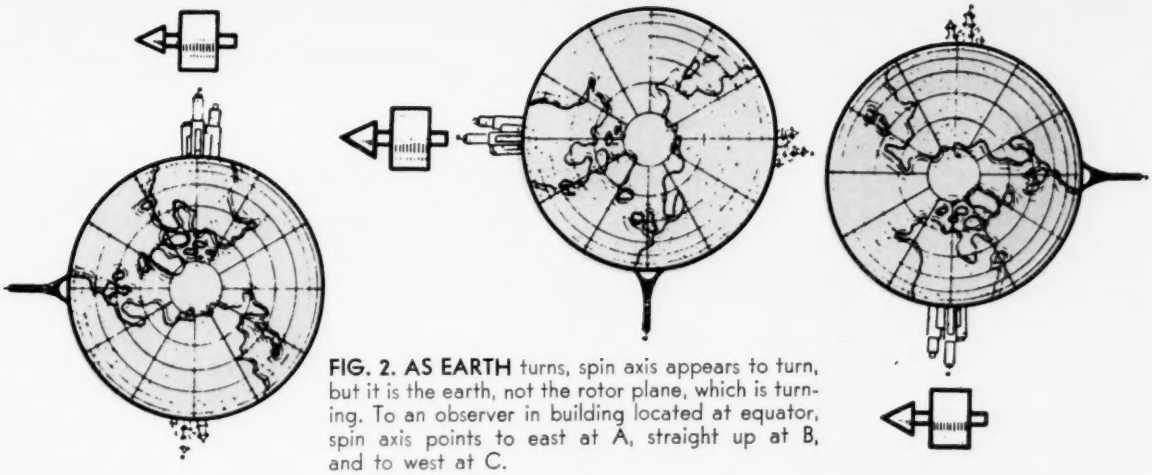


FIG. 2. AS EARTH turns, spin axis appears to turn, but it is the earth, not the rotor plane, which is turning. To an observer in building located at equator, spin axis points to east at A, straight up at B, and to west at C.

used in conjunction with precession to make possible gyroscopic indication of bearing (gyrocompass).

Precession

Precession is the second useful property of the gyroscope, and is used in instrumentation. If a force is applied to the axis of a spinning gyroscope, the axis rotates in a direction 90° from (at right angles to!) the direction in which the force is applied. This mysterious-seeming phenomenon is known as precession. In Fig. 3, a force F, applied as shown (in direction of axis X-X′) causes precession *around* axis Y-Y′. The axis X-X′ will start turning as shown by the dotted arrow, at right angles to the applied force F.

Fig. 4 shows why precession occurs. Let us assume that the mass of the rotor is concentrated at points A, B, C, and D. If a force F is applied into the page at the point shown, it tends to turn the rotor around axis Z-Z′. If the rotor were not spinning, point A would move down, point C would move up, and points B and D would not be affected. However, because the rotor is spinning, point A is moving to the left, and the effect of force F is to cause it to move *downward and to the left.* Similarly, point C is moving to the right, so that the result of force F is motion *upward and to the right.* As B and D are not affected by force F, their motion continues unaffected. As point A moves downward and to the left, and point B moves upward and to the right, the rotor turns about the axis Y-Y′, instead of the axis Z-Z′.

As the *rate* of precession is proportional to the applied force F, precession can be used to measure the applied force F, to convert a force into a torque or angular rotation, to integrate a force, etc. For example, the *number* of rotations due to precession, would be proportional to the product of force (F) and time (t). A gyro integrator using this principle is used in a new mass flowmeter.

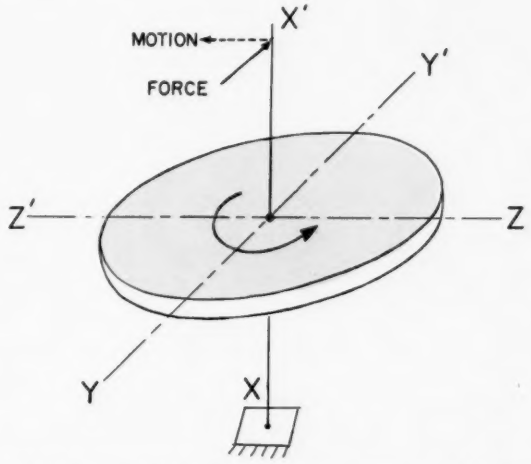


FIG. 3. FORCE F applied to gyro causes axis X-X′ to precess at right angles to the applied force.

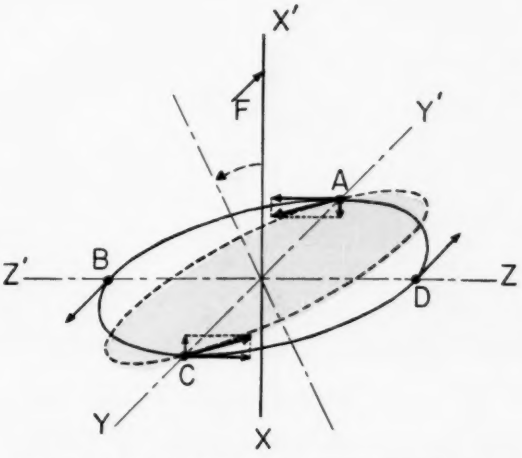
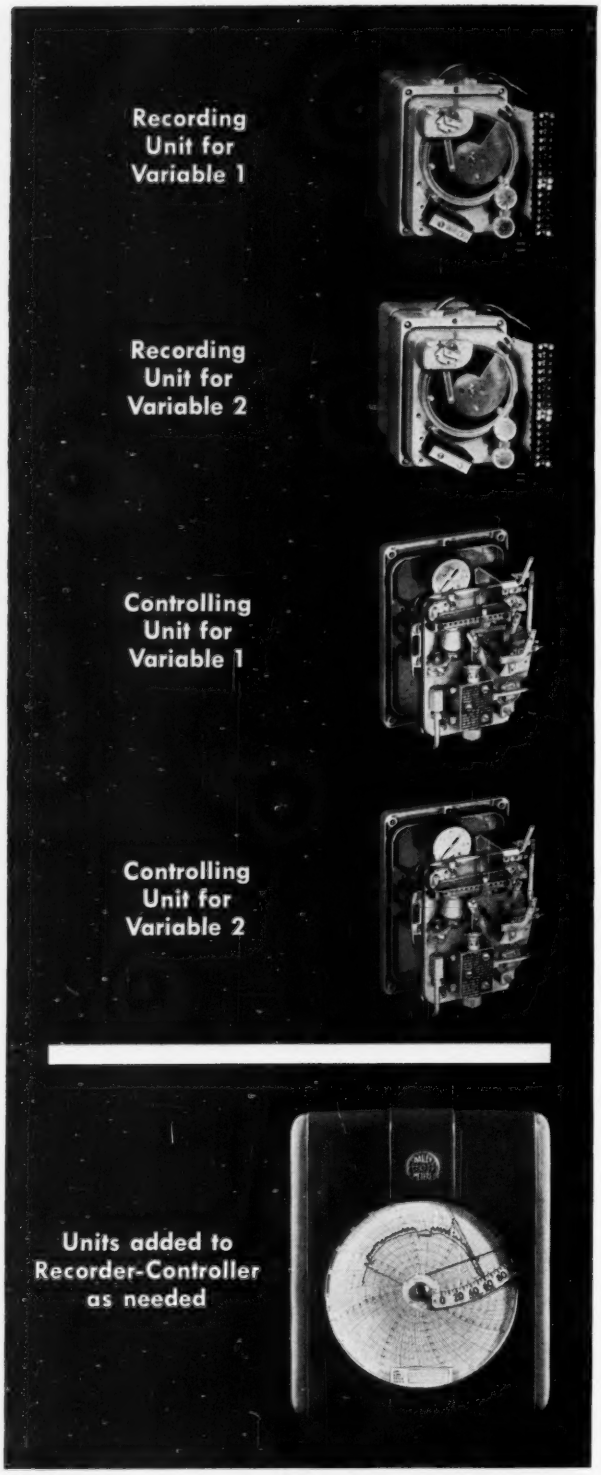


FIG. 4. THE REASON why precession occurs. If point A moves down and to the left, and if point C moves up and to the right, then axis X-X′ must precess as shown.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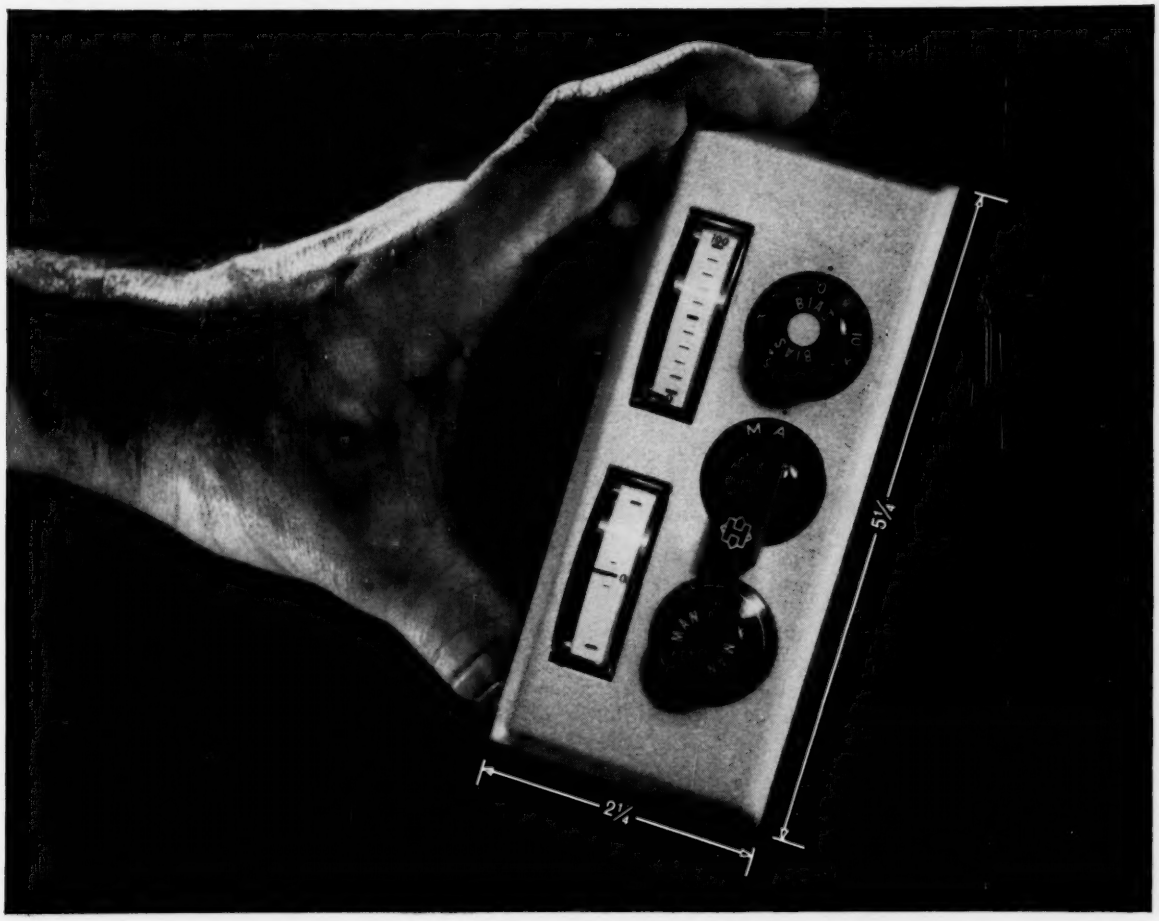

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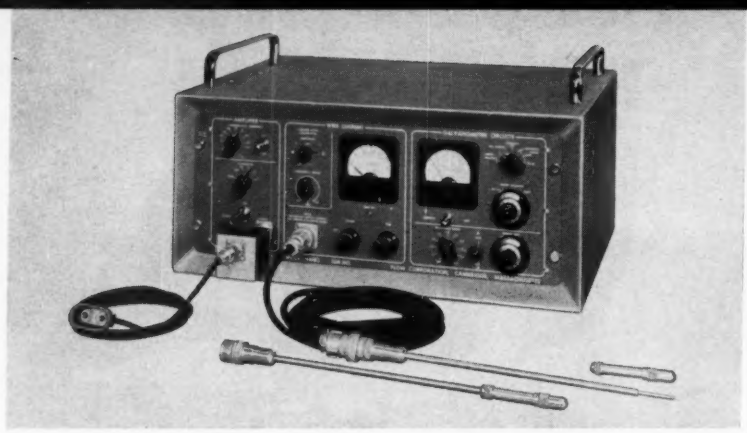

FIG. 1. MODEL HWB-2 constant-current hot-wire anemometer.

The Hot-Wire Anemometer

The hot-wire anemometer is an instrument for convenient measurement of rapidly fluctuating velocities and temperatures:

O. C. WOLF
Flow Corporation

THE HOT-WIRE ANEMOMETER is an instrument used for measuring instantaneous velocities in a fluid stream, through the stream's cooling effect on a thin, electrically-heated wire filament. Such instruments were used first about 70 years ago to measure wind velocities (hence the name "anemometer"), but it was not until the first world war that serious scientific interest was aroused, and not until after the second that use of hot-wire instruments became wide spread.

The first major application was in the study of turbulence in air streams. It was known that the tendency of an air flow to lose its smooth laminar character and to break into small random turbulent eddies was of considerable importance in a number of aerodynamic problems (e.g., separation of boundary layers); the use of hot-wire probes permitted not only oscilloscope portrayal of turbulent velocity fluctuations but also a numerical investigation of their magnitudes.

Perhaps the most extensive application at the present time, however, is in the study of air flows in jet-engine components. For example, the fuel consumption of a jet engine depends on the efficiency of its compressor, which in turn depends on the detailed behavior of the air flow in its blading. Hot-wire instruments are used to examine the air flow pattern around each blade in compressors and turbines even where as many as 20,000 blades per second pass the hot wire.

Other current uses of hot-wire instruments (Fig. 1) include: (1) blade misalignment tests on air-conditioning fans and pumps—a glance at an oscilloscope shows whether or not all blades are properly aligned), (2) measurement of average velocity, particularly where the velocity is fluctuating so that conventional pitot-static probes give unreliable readings, (3) measurement of temperature and temperature fluctuations, taking advantage of the fact that an unheated "hot wire" is a simple resistance thermometer with great sensitivity and rapid response, (4) high-temperature investigations (probes can be built to withstand 1500°F), (5) analysis of sound waves, which, being associated with velocity fluctuations, can be reproduced clearly by hot-wire instruments, (6) study of vortices, (7) study of transitions from laminar to turbulent flow, (8) shock-tube measurements, (9) study of supersonic flow, etc.

Hot-wire instruments have been used successfully in gases other than air, and to some extent in liquids, such as clean, degassed water.

Principle

A hot-wire probe has at its working end a thin wire (typically about 0.04" long and 0.0003" diameter) through which an electric heating current is passed. The voltage across the hot wire can be amplified and presented on an oscilloscope. This voltage depends on the electrical resistance of the hot wire, which depends on its temperature; in turn, its temperature depends on the cooling effect of the air stream. As the wire is small, the instrument can respond rapidly to fluctuations in air velocity. In measuring average velocities, the time-average voltage across the hot-wire can be measured with a potentiometer and the corresponding velocity then obtained from a calibration curve.

The hot-wire itself is usually tungsten or platinum alloy, soldered or welded at each end to supporting needles. Well-made hot wires last indefinitely in normal use; if accidentally broken a new wire can be mounted on the same probe.

Circuitry

Two types of circuitry—*constant current* and *constant temperature*—have been used with hot-wire instruments. In the constant-current system, the heating current is kept constant (usually by placing a large fixed resistor in series with the hot-wire) and the voltage across the hot wire is examined. In this system the response of the hot wire to a velocity fluctuation is modified by its

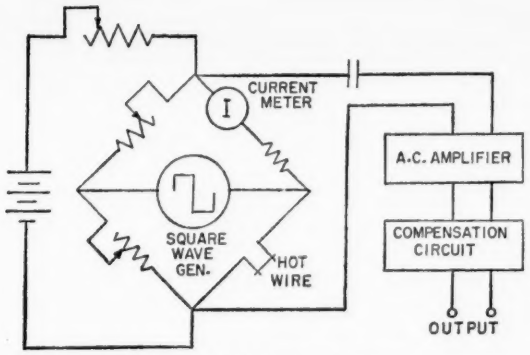

FIG. 2. BLOCK DIAGRAM of constant-current circuit showing square-wave calibration circuit.

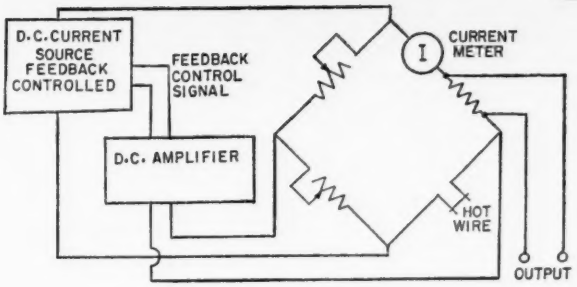

FIG. 3. BLOCK DIAGRAM of constant-temperature circuit.

own internal heat capacity, which becomes important for fluctuation frequencies above about 50 cps. It is therefore necessary in the constant-current type of instrument, when examining velocity fluctuations, to include a compensating circuit in the amplifier which automatically corrects for this internal heat capacity.

The appropriate setting of the compensation circuit depends on the operating conditions of the hot wire, and is usually found by what is called a "square-wave calibration circuit" (Fig. 2). The method depends on the well-established fact that when a small square-wave current is superposed on the steady heating current of the hot wire, the amplifier output as seen on an oscilloscope will reproduce this square-wave pattern only when the compensation control is set correctly. A useful frequency range of 100,000 cps or more can be achieved in the constant-current system.

In the constant-temperature type of instrument (Fig. 3), a feedback circuit maintains constant the resistance—and so the temperature—of the hot wire. The energy input to the hot wire then must go entirely into the air stream; the internal capacity of the hot wire is no longer of importance, because its temperature is constant, and consequently this energy input (proportional to the square of the current) is a measure of the instantaneous air velocity.

While the constant-temperature system presents apparent theoretical advantages it is subject to some serious design limitations. The upper frequency limit of the feedback amplifier must be more than twice the useful frequency range of the instrument, so that to match the performance of the best constant-current systems requires excessively high-frequency operation with associated problems of stability. Noise levels are generally higher and drift in the high-gain d-c amplifiers must be controlled carefully. High-capacity power supplies must be regulated to better than 0.001%, which implies expense and bulk. Operationally, while the constant-current system requires compensation, the constant-temperature system requires an amplifier null.

The constant-current instrument has a further advantage. It turns out that when the square-wave method has been used to set the compensation circuit correctly, the size of the square-wave signal at the amplifier output (as presented on an oscilloscope, or measured on an rms meter) automatically determines the proportionality between velocity fluctuations and signal output. As a consequence, quantitative work with constant-current equipment is usually easier than with constant-temperature equipment.

For these reasons constant-current equipment is now the primary choice for quantitative work, although, with continuing development effort, we may eventually see constant-temperature equipment with performance matching the best constant-current equipment available today.

A special variation of the constant-temperature principle called *constant resistance ratio* employs two sensing wires (operating at different currents) exposed to the stream. A special circuit automatically maintains the ratio of their two resistances at a constant value. This scheme, although slightly sacrificing rapid response, provides high stability and minimizes the effect of stream temperature variations.

Constant-resistance-ratio anemometers are of greatest interest in a wide variety of commercial air and gas flow applications. The accurate measurement of air flow is becoming increasingly important to air conditioning, heating and ventilating engineers. Gas producing, distributing and utility companies now can get stable, repeatable velocity readings at any point in their vast underground network of pipes and mains. The monitoring of air-flow patterns around electronic and mechanical components to determine cooling effects of fans and blowers is of extreme value to design engineers.

The use of constant-resistance-ratio anemometers also shows great promise in the medical research field. Breathing and respiration patterns as monitored by a chart recorder or electrocardiograph are being studied by a number of medical groups.

Inexpensive, easy-to-operate equipment now available has brought the hot-wire anemometer out of the province of specialized research into everyday use. It is at present the only convenient instrument for the measurement of fluctuating velocities and temperatures, and it is the most sensitive instrument available for measurement of low steady velocities.

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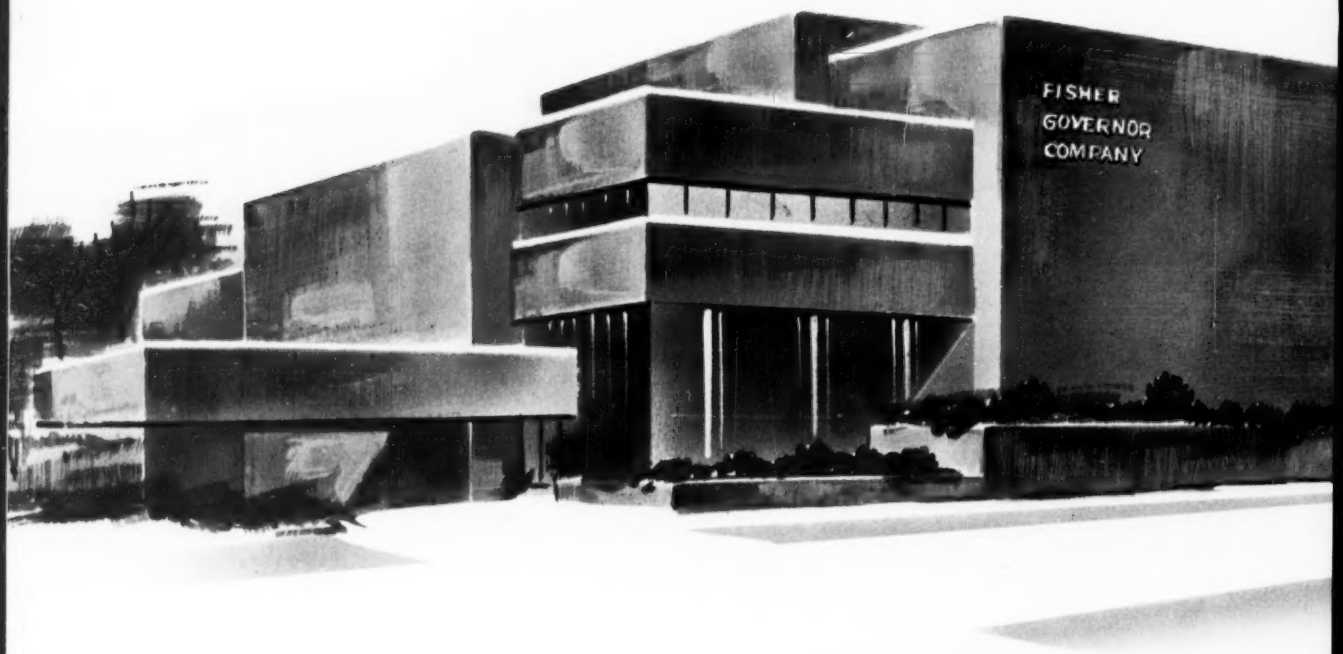

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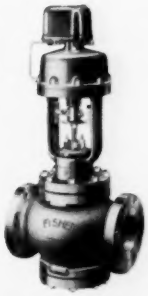
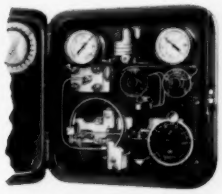
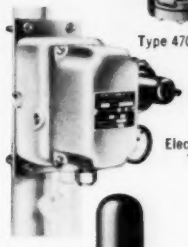


Type 470 P.O.P.



Wizard II
Pressure Controller



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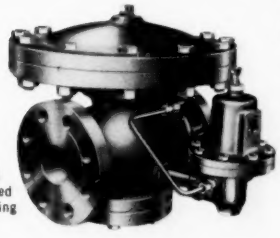
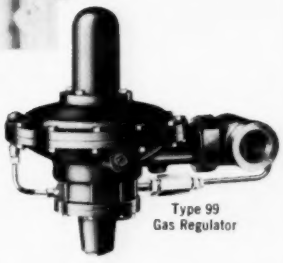
Electro-Pneumatic
Transducer

Type 350
Electro-Hydraulic
Control Valve



Type 92-B
Pilot-Operated
Steam Reducing
Valve



Type 99
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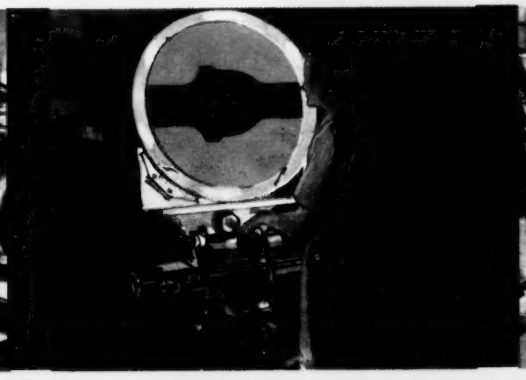
Various new style grinders produce a super-finish on Fisher valve guides and bushings, second to none in the industry. It is typical of precision manufacturing methods that assure long, trouble-free operation of Fisher controls in the field.



RIGID INSPECTION PROCEDURES
The highest ratio of inspection personnel to production personnel, in the control valve industry, is maintained at Fisher. As a typical example, there are no less than 704 inspection operations performed on a 4" Type 657-A diaphragm motor valve.

EFFICIENT FIELD SERVICE
"Supermarket" 36-hour delivery, from the factory, on popular sizes and types of controls is only one of many services available to Fisher customers. 17 sales offices throughout the country maintain field stocks for immediate delivery.

JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION

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Mass Flow

Axial-flow, radial-flow, gyroscopic, vortex velocity, and thermal devices are available to measure the mass flow of fluids.

DEMAND for mass flow measurement has increased sharply. In many industrial processes the product is sold on a weight basis, and efficiency is measured by the consumption and output of material on a gravimetric base; users of jet aircraft and liquid-propelled missiles must know the weight consumption of fuel or propellant.

There are two approaches—(1) *compensation*—that is, measure the volumetric flow rate and multiply the volume by the fluid density—or (2) measure *mass flow* directly. The demand for mass-flow-measuring devices has resulted in refinement and improvement of compensation practices and in the development of new mass-flow-measurement principles and devices.

Compensation Technique

The differential-pressure meter (orifice, venturi, nozzle) furnishes an output signal which is directly proportional to ρV^2, where ρ = density and V = velocity of the fluid being measured. If the fluid density and meter area are known, the square-root of the output signal will yield *volumetric* flow rate. If this reading is then multiplied by the fluid density, the product is an indication of mass flow rate.

In order to meet the demand for mass-flow measurement every major differential-pressure meter manufacturer now offers compensating devices which obtain the density of a fluid by (1) measuring its temperature and pressure, (2) extracting the square root of the differential-pressure reading, and (3) multiplying the factors appropriately to record mass flow rate. (An extensive survey of these devices was published in an article entitled "Compensation Practice" which appeared in the August 1959 issue of *Instruments and Control Systems.*)

These compensated mass-flow-measuring systems are far from ideal because (1) the relationship between density of fluid being metered and its temperature and pressure must be known, (2) more than one primary metering element is required, increasing the chance for malfunction, (3) the system frequency-response is slow because of the many mechanical or pneumatic linkages that make up the compensation system, and (4) its range is limited because of the square-root relationship between flow and differential pressure in the primary flow element.

The signal from a meter that measures velocity (V) can be multiplied by the signal from a densitometer (ρ) to give the resultant ρV term. Velocity meters include the turbine meter, magnetic flowmeter, and the ultrasonic flow meter. For example, Foxboro uses a magnetic flowmeter plus a radioactivity-type densitometer to measure mass flow directly.

A number of mass flowmeters developed recently use the angular-momentum principle to measure mass flow directly.

Angular Momentum Types

The relationship of angular momentum to torque can be described by Newton's Second Law of Angular Motion:

If H = angular momentum (lb-ft-sec), I = moment of inertia (lb-ft^2), ω = angular velocity (rad/sec), α = angular acceleration (rad/sec^2), T = torque (ft-lb), r = radius of gyration (ft), m = mass (lb), t = time (sec), then:

$$T = I\alpha \quad (1)$$
$$H = I\omega \quad (2)$$

As $I = mr^2$ (by definition) equations (1) and (2) become:

$$T = mr^2\alpha \quad (3)$$
$$H = mr^2\omega \quad (4)$$

As $\alpha = \omega/t$, equation (3) changes to:

CIRCLE 63 ON READER-SERVICE CARD

Measurement

ROBERT SIEV
Aerojet-General Corporation
General Tire & Rubber Company

$$T = (m/t)r^2\omega \quad (5)$$
$$H/t = T = (m/t)r^2\omega \quad (6)$$
$$m/t = T/r^2\omega \quad (7)$$

As torque is in terms of force, the right-hand side of equation (7) must be multiplied by g (32.2 ft/sec^2) to obtain a dimensionally-correct equation. If r^2 is a constant (for any given system), and ω is known, we can determine the mass flow of a fluid if (1) we induce an angular momentum into the fluid stream and (2) then measure the torque produced by this angular momentum and the fluid's angular velocity.

A number of methods have been proposed by which this relationship between angular momentum and torque can be employed to measure mass flow.

GE Uses Driven Impeller to Develop Angular Momentum

In the GE mass flow meter (Fig. 2) an angular momentum is imparted to the flowing fluid by an impeller which is driven at a contant speed by a synchronous motor. A turbine downstream of the impeller recovers the fluid's angular momentum. The turbine is restrained by a spring which deflects through an angle proportional to the torque exerted upon it by the fluid. This meter has found acceptance for in-flight refueling applications (co-developer Black, Sivalls and Bryson also markets this meter and excercises exclusive rights in the natural gas industry).

The torque (mass flow rate) is integrated in this instrument to give totalized mass flow by means of a gyro integrator.

Standard flow ratings are from 2500 to 40,000 pounds per hour for gases and 20,000 to 240,000 pph for liquids. Rangeability as 10:1; max operating pressure is 1500 psig. Viscosity limits (for liquids only) are 0-100 centipoise. Accuracy is within 1% of measured value, repeatability is ±¼%.

FIG. 1. GE mass flowmeter.

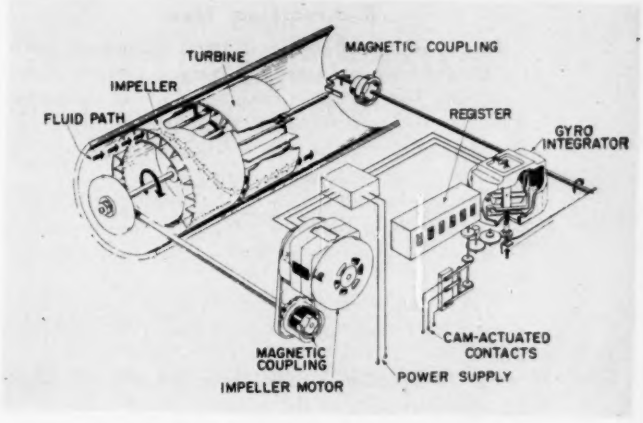


FIG. 2. GE mass flowmeter uses motor-driven impeller to impart angular momentum to fluid. Spring-restrained turbine recovers the angular momentum.

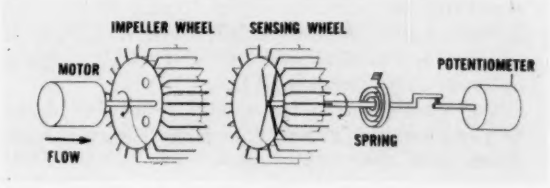
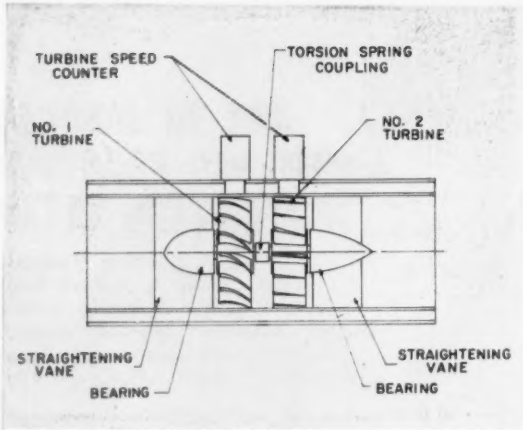


FIG. 3. AVIEN mass flowmeter.



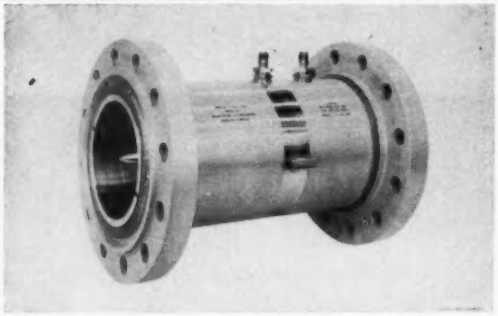


FIG. 4. POTTER Aeronautical uses fluid-driven twin turbines with different blade angles.

Avien Uses Driven Impeller for Bi-Directional Flow

Avien, Inc., also offers a mass flowmeter with driven impeller and spring-restrained sensing wheel (Fig. 3). The spring is designed for the mass-rate spectrum to be measured. For applications with different mass rates, the only modification required is to incorporate a suitable spring.

The angular deflection of the sensing wheel can be coupled to a potentiometer (for uni-directional flow) or to a magnetic sensor (for bi-directional flow).

When used with a potentiometer, a servo system is used for remote indication of flow rate, as shown in Fig. 3.

For bi-directional flow, there are two impellers on opposite sides of the sensing wheel, rotating in opposite directions. Thus, when flow is in one direction a clockwise torque is developed on the sensing wheel; when flow reverses a counterclockwise torque is developed. An E-bridge arrangement is usually used (rather than a potentiometer) to sense the displacement of the sensing wheel. The E bridge gives an a-c output whose amplitude is proportional to mass flow rate and whose phase is determined by direction of flow.

For totalization, a tachometer generator geared to a counter adds as flow goes in one direction, subtracts as it goes in the other.

Applications have been made on aircraft fuel flow. Accuracy is 2% of aircraft cruise range.

Potter Aeronautical Uses Fluid-Driven Twin Turbines

The twin-turbine mass flowmeter developed by the Potter Aeronautical Co. is shown in Fig. 4. A reluctance-type pickup coil is mounted over each turbine, and a sharp pulse is generated in each of the respective coils by each of the corresponding turbines for each 360° revolution.

The two rotors have different blade angles and are coupled together by a spring. As a result of the blade-angle difference, the two rotors tend to rotate at different speeds, but cannot because of the spring coupling. They thus take an angular displacement with respect to each other, which is proportional to the flow momentum. The momentum is equal to the mass flow rate multiplied by the velocity (ρV^2). However, the whole rotor assembly considered as a unit acts like a simple turbine meter, rotating at a speed proportional to the average fluid velocity (V). The time per revolution (or per fraction of a revolution) is thus inversely proportional to the fluid velocity (1/V).

By measuring the elapsed time between the pulses produced by the two rotors, we measure the fluid momentum divided by the fluid velocity. Thus, the elapsed time between indexed pulses on the two rotors is directly proportional to the mass flow rate. This signal can be time-integrated electronically to provide total pounds.

The period of time is measured as follows: As each turbine magnet passes its pick-up coil, the coil generates a pulse. The pulse from the upstream turbine is used to open an electronic gate, while the pulse from the downstream turbine closes this electronic gate. An oscillator operates while the gate is opened. Thus the number of oscillations per second provides mass flow rate. Totalization is done simply by counting pulses. This mass flowmeter does not require a motor-drive unit.

Meters range in size from 2″ to 10″. Accuracy is ±0.5% of reading over a 10-to-1 linear range.

Rotron Measures RPM of an Induced Eddy

The Rotron Vortex-Velocity* flowmeters (Fig. 5) have a continuous flow rangeability of 10 to 1 regardless of meter size. They will measure liquids, atmospheric air, or compressed gases. Temperature limits can range from a minimum of 32°F to 200°F. (Meter is available from the Industrial Div., Minneapolis-Honeywell Regulator Co.)

The Vortex-Velocity flowmeter consists essentially of a piece of straight pipe with an offset cylindrical chamber. When a fluid flows through the pipe, an eddy or vortex forms in the chamber. The rotation of the vortex is inherently proportional to the main flow in the pipe. A rotor mounted in this vortex senses the vortex promptly and maintains its stability. The rotor merely rides with the vortex as a means of counting its revolutions. A magnetic coupling between the rotor shaft and the register eliminates the need for packing glands.

Counting the number of revolutions, or speed of

*Trademark, Rotron Control Corp., Woodstock, N. Y.

the vortex, produces an accurate volume total or flow rate indication of mass flow at line conditions. The meters have an accuracy of 0.5% and a flow range of 20 to 200 gpm for liquids, and 10 to 100 cf/min for gas.

Coriolis Principle is used in Radial-Flow Angular-Momentum Meter

This version of the angular-momentum mass flowmeter is called "radial flow" because the fluid flows along the radius of the rotating element as it passes through it. It is based on the Coriolis principle, and was described by Dr. Y. T. Li and Dr. S. Y. Lee of the Massachusetts Institute of Technology.*

The radial-flow angular-momentum mass flowmeter basically consists of an impeller similar to those used in centrifugal pumps, a flowmeter housing which is rotated at a constant speed by an external motor, and a torque tube which connects the housing to the impeller and which senses the torque produced between the impeller and its housin. The impeller consists of radial vanes; the fluid enters the flowmeter at the center of the impeller and as it flows along the radial sections it is forced to the impeller's circumference. Thus, every fluid particle has two distinct and separate properties of motion as it passes through the flowmeter: (1) angular velocity due to the rotation of the impeller and (2) an acceleration along the radius of the impeller, the *Coriolis acceleration*. The mass flow rate can be shown to be proportional to this acceleration.

Gyroscopic Angular Momentum

Another angular-momentum mass flowmeter (Fig. 6) operates on the principle of a gyroscope. It consists of a pipe shaped in the form of a circle or a square. A motor rotates this assembly at a constant angular velocity ω about the A axis. When fluid passes through it, a precession-type moment is produced about the B axis and is measured by the deflection of a sensing element. This deflection can be shown to be directly proportional to mass flow.

A variation of this type of flowmeter has been invented by Dr. W. Roth, and developed and marketed by the Decker Corporation of Bala-Cynwyd, Pa. In this gyroscopic mass flowmeter the pipe assembly, instead of rotating at a constant angular velocity, is oscillated at constant frequency and amplitude.

Accuracy is ±½% full scale over 20-1 flow range. Present production units cover 500 lb/min range. Other ranges available.

Mass Flowmeters Using Temperature

Mass flow can be measured by using the amount of heat that the flowing fluid picks up from a heated thermopile, a heated platinum resistance winding, or a heated pipe.

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*"A Fast-Response True-Mass-Rate Flowmeter," *Trans. ASME*, Vol. 75, 1953, p 835-841.

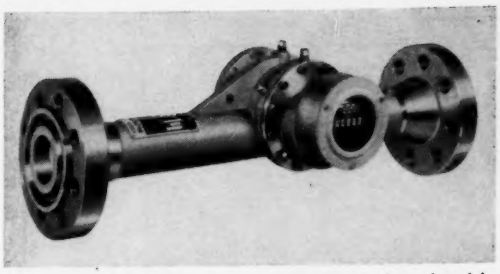


FIG. 5. **ROTRON** meter measures induced eddy velocity. (Photo courtesy Minneapolis-Honeywell, Ind. Div.)

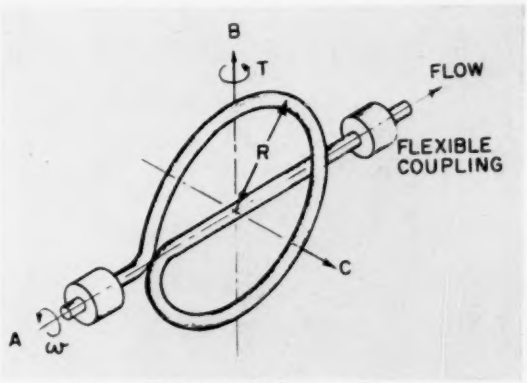


FIG. 6. **GYROSCOPIC** mass flowmeter.

Hastings-Raydist Uses Directly Heated Noble-Metal Thermopile

The heated-thermopile principle (Fig. 7) has found wide application in the measurement of velocity, flow, pressure and vacuum; it can be used also to measure gas flow. A low-voltage a-c bridge circuit has two noble-metal thermocouples (A, B) as sensing elements. The thermocouples are heated by alternating current. A change in flow causes a change in temperature of the thermocouples, resulting in d-c output of the thermocouples.

A third thermocouple (C) is included in the d-c meter circuit. This couple is unheated and is the same size as those in the d-c circuit. A change in ambient temperature develops voltages in all the thermocouples, but the transient effects in heated and unheated elements are equal and opposite, so the unheated couple compensates for change in ambient temperature. The thermopile instrument is a mass flowmeter so long as $\sqrt{KS\rho}$ is a constant, where K is the thermal conductivity, S is the specific heat at constant volume, and ρ is the density. Fortunately, this term is a constant for most gases over wide ranges of temperatures and pressures. Thus the instrument can be calibrated directly in terms of pounds of gas per hour passing the thermopile.

Accuracy is approximately 2%. Ranges available

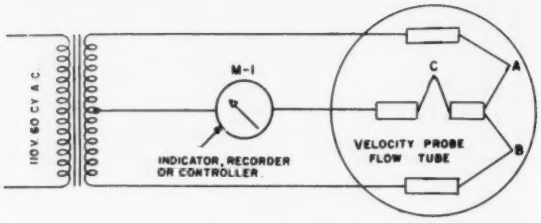


FIG. 7. HASTINGS-RAYDIST heated-thermopile mass-flowmeter principle.

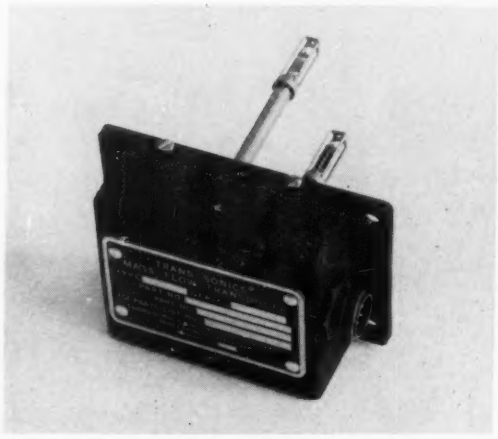
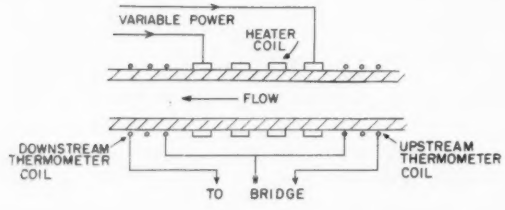


FIG. 8. TRANS-SONICS mass flowmeter uses heat transfer from platinum resistance thermometer.



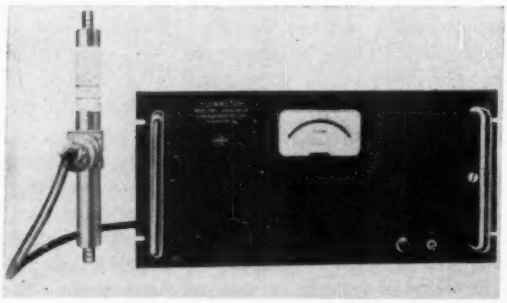


FIG. 9. THERMAL flowmeter uses heated coil on outside of flow tube.

are from 500 cc/min to 30 cf/min. Major uses have been with air and hydrocarbon gases.

Trans-Sonics Mass Flowmeter Uses a Heated Platinum Resistance Probe

The Type 1994 Mass Flow Transducer (Fig. 8) consists of two platinum temperature probes (P1 and P2) extending from a small compact case. The platinum resistance windings, located at the ends of the probes and protected by stainless-steel cages, are the active elements in opposite arms of a d-c resistance bridge.

The platinum resistance windings make the basic temperature measurements from which the total mass flow in the duct is determined. When the transducer is installed, the longer probe places a platinum resistance winding at the centerline of the duct. This resistance is heated by a relatively high current and, in accordance with laws of heat transfer, makes the fundamental density-velocity measurement as it is cooled by the mass flow in the duct.

The remaining platinum resistance winding on the shorter probe is essentially unheated and is therefore not significantly affected by mass flow. It compensates for changes in the gas temperature in the duct by introducing a voltage which cancels out any bridge unbalance caused by the gas temperature's effect on the longer sensing probe.

Zener diodes regulate input voltage; thus the rate of heat transfer is a function only of the rate of mass flow.

The mass flow rate is typically displayed on a d-c microammeter calibrated to 180 pounds per minute of conditioned air flowing to the flight deck or to the passenger cabin of a jet aircraft. Accuracy in such applications is 3% of full scale.

Flow Measurement's Thermal Flowmeter

The Thermal Flowmeter shown in Fig. 9 is available from Flow Measurements Corp.

Heat is produced electrically in a heater coil, wound around the outside of the flow tube, Differential temperature between two thermometer coils, one upstream and one downstream of the heater determines the output voltage supplied to the amplifier. This temperature differential is a function of both the fluid mass flow rate and the power dissipated in the heater coil.

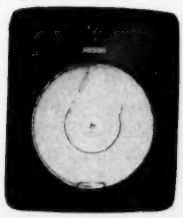
A constant temperature differential (about 1°C) is maintained at all flow rates by means of a self-balancing bridge incorporating the two resistance thermometers. Wattage is varied automatically by the electronic control system in response to the varying flow rates. The direction of change of power input to the heater is such as to restore the bridge balance, thus providing a closed servo-loop system.

Instrument covers 10-to-1 flow ranges from 1 pound per hour up. It is for use on corrosive fluids, for sanitary service, or other applications which would make the smooth-bore, welded, stainless-steel construction of the flowcell desirable. Accuracy is to 1%, depending on application.

Foxboro pH Dynalog Recorder has an input impedance of 80,000 megohms — eliminates the need for intermediate amplification. Span is adjustable from 2-12 pH; zero, from 0-12 pH.

Foxboro eliminates the amplifier from pH recording and control

cuts the drift, cuts the cost, cuts the maintenance, too!



Foxboro pH Dynalog Controller — for use where it is desired to hold pH at a predetermined value.

Foxboro pH Dynalog Indicator — for use where complete record of pH value is not required.

THAT'S RIGHT — the intermediate amplifier is gone from Foxboro's new low-cost system for measuring pH. And gone with it is the wasted panel space, the drift, the daily standardization inherent with earlier systems.

In the new Foxboro system, the signal from the pH electrode goes direct to a high impedance Dynalog* receiver — without intermediate amplification. Signal operates a direct-reading indicator or recorder—or a controller and alarms, when desired.

The new Foxboro pH system is the simplest, most economical method of measuring pH available today. Ask your Foxboro Field Engineer to tell you about it. Or write for data sheet. The Foxboro Company, 466 Neponset Avenue, Foxboro, Massachusetts.

*Reg. U.S. Pat. Off.

FOXBORO Analytical Instrumentation

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CIRCLE 64 ON READER-SERVICE CARD

ELECTRONIC CONTROL OF PIPELINES

P. H. DRINKER, The Foxboro Company

Here is how new electronic control instruments can handle seven unusual and particular requirements of pipeline applications with superior performance, reliability and convenience. These techniques (automatic selection of controllers in multivariable systems, anti-windup for rapid control action, and function generators for start-up) also are useful in critical chemical reactions, protective circuits, batch processes, heat-exchange processes, etc.

TO A "PIPELINER," instrumentation and automatic control carry a different meaning than they do to process engineers in refineries and chemical plants. Last winter, at an important conference of instrument users and manufacturers, a number of pipeline control problems were aired.

1. *Automatic Control Selection;* control of pipeline variables only when they reach preset values, no control otherwise being effected.
2. *Control of Sudden Upsets;* the system must react soon enough to prevent station shutdown but at no penalty to continuous control when it is required.
3. *Control of Station Start-ups;* single and multi-pump installations.
4. *Large Overrange of Measurements.*
5. *Telemetering and Remote Control* with set points easily adjusted.
6. *Unattended Instrumentation.*
7. *Control Valve Characteristics;* the valve needs the conflicting requirement of being full open most of the time, yet should have throttling control without overshoot.

Such specifications are tough, but they are not new problems; there are successfully operating pneumatic systems in each case listed. However, electronics may offer more convenient solutions.

Automatic Selection Systems

This application is familiar. Let us consider a 3-element system (Fig. 1) in which suction pressure, discharge pressure and motor load are controlled. For proper pumping the input pressure must not be too low or the output pressure too high (otherwise you get cavitation or burst a pipe or burn up a big motor).

Fig. 2 shows how the controllers are connected so that the one with largest output signal over-rides the others. The system can just as well be arranged so that the lowest output is selected. The valve may be current-to-open or current-to-close, as required.

This system does have definite limitations when a station is running with all variables on the safe side of their set points—that is, suction pressure high, discharge pressure low, and motor load low. In this case each controller will drive the valve open (as desired much of the time in pipeline pumping) but there is no control until one of the variables crosses its set point.

Under such conditions the control circuits can be said to be at their extreme (saturated) positions. The reset circuit, in particular, is critical when saturated because of its long time-constant. For example, if the reset capacitor is fully charged, it does not discharge rapidly, and it keeps the regular proportional control circuit from operating until the variable crosses the set point, as shown in Fig. 3A.*

Presented at the 32nd Annual Conference and Exhibition of the Petroleum Industry Electrical Association and Petroleum Electric Supply Association, April 13, 1960.

*"*Windup*" is a term describing the condition of a controller when the reset and proportional bellows are at full supply pressure because an error has persisted long enough to cause that condition. Usually this occurs in a batch process when steam to the batch reactor is shut off, but it also occurs on pipelines under the conditions described. Most controllers require that the sign of the error be reversed—i.e., measurement must cross set-point before the reset circuit will be "un-wound."

When the variable (usually suction pressure) changes slowly, and when the set point is not too close to the shut-down point, recovery will be fast enough to keep the station operating. However, should a variable change rapidly, there will be significant overshoot before control action can be effected, and the station will most likely shut down on low suction pressure.

Control of Sudden Upsets

To cope with the situation described, electronic instruments have been designed with circuitry providing for output response well before the normal set-point is reached; the feature is known as *anti-windup*. The anti-windup circuit simply discharges (or charges) the reset capacitor.

Fig. 3A shows how the control system might operate with conventional controllers. The valve position is shown at top (referenced to the scale at the right). The suction pressure is shown as "measured variable." The proportional band of the controller is shown referenced to the scale at the left. The desired suction pressure is the horizontal line.

In the beginning of the situation, the suction pressure is shown at control point but to hold it there the valve is nearly closed, owing perhaps to an emergency shutdown upstream or high-density product approaching the station.

In time, the suction pressure will rise again as the emergency condition remedies and the suction pressure controller will open the valve wide, still holding the suction pressure at the set point until the valve reaches limits. Then, assuming that the other controllers are inoperative, the valve will remain open until the suction pressure falls all the way to set point again (time t_1), and this could result in overshoot.

The valve can be made to start controlling the flow *before* the normal set point is reached (such as at time t_2) by raising the proportional band as shown in Fig. 3B. The band can be raised an adjustable amount (called adjustable limit) in Fig. 3B by the "anti-windup" circuit shown in Fig. 4.

The anti-windup circuit uses a relay actuated by the control output to discharge the reset capacitor.

The amount which the proportional band is raised above the set point is adjustable (for different valves, different pumps, and different line characteristics) in order that the amount of "unwinding" can be tuned to prevent overshoot just as other controller adjustments are properly tuned to the process. Furthermore, if requirements are such that the valve must be current-to-close, rather than current-to-open, the same circuitry still can be applied, only the addition of a switch being necessary to reverse its action. While pipelines do not require it, other processes occassionally demand "anti-windup" from both sides of the set point in the same system; this too can be accommodated.

One important point—as it is always desirable on a pipeline to have the valve as far open as possible, no design is acceptable which results in a

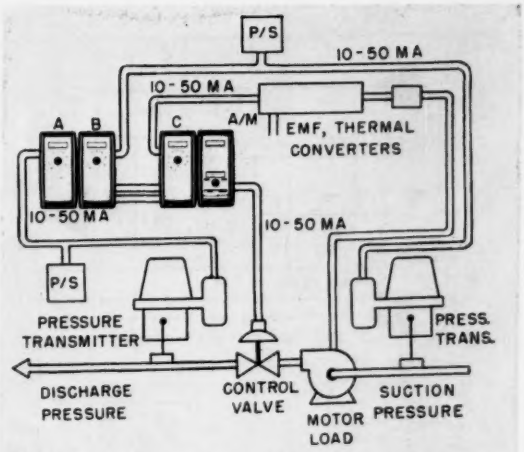


FIG. 1. AUTOMATIC SELECTOR system. If suction (input pressure) is low, controller B operates; if discharge is high, controller A operates; if motor load is high, controller C operates; otherwise there is no control action and valve is wide open. A/M is automatic-manual station.

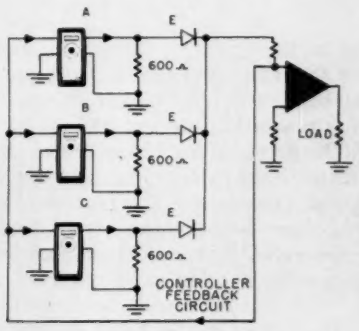


FIG. 2. SIMPLE CONNECTIONS via diodes E permit largest (or smallest) signal to assume control of system.

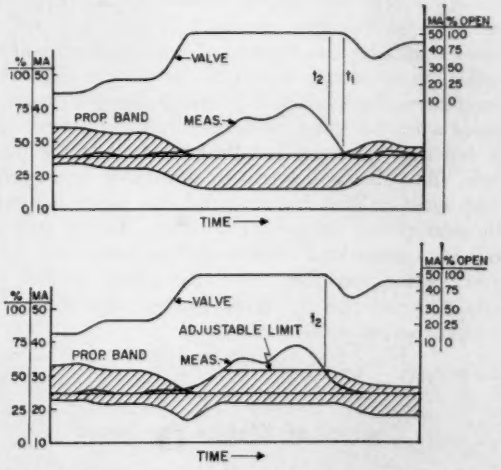


FIG. 3. PROCESS reaction curves showing recovery from identical load upsets—above, controller without anti-windup; below, controller with reset anti-windup feature.

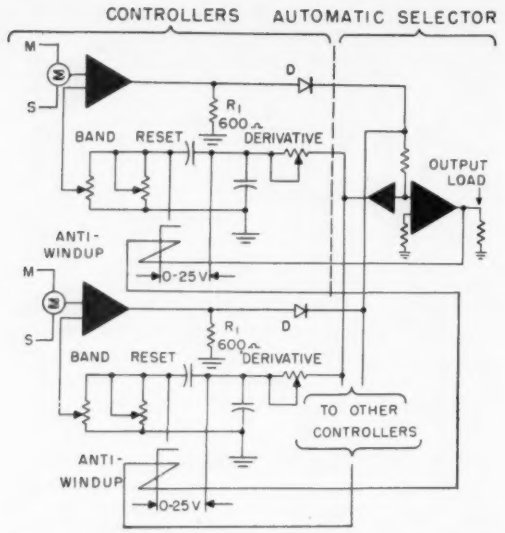


FIG. 4. CIRCUIT for anti-windup and automatic selection of controller. Anti-windup circuit includes relay which discharges reset capacitor, permitting early proportional action control.

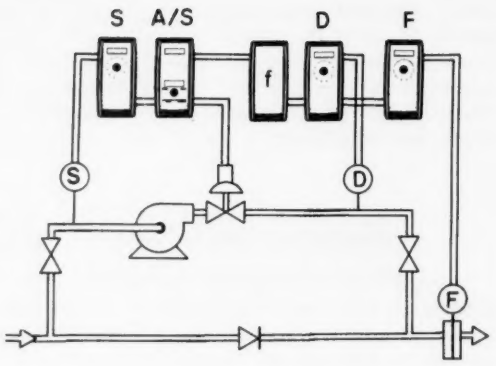


FIG. 5. RAMP GENERATOR (f) for startup. S is suction-pressure controller, D is discharge-pressure controller, F is flow controller, A/S is manual-automatic selector. System selects lowest signal for operation. At start-up all signals are large, except that from f.

throttling action where it is not necessary. It is important to note that in this arrangement the proportional band will not be moved upwards until output has reached 50 ma, or 100% of its scale, so there will be no throttling unless a load change demands it, no matter how close pressure comes to the set point. Observe the first portion of the curve in Fig. 3, where load changes were causing reset to open the valve. Not until it reached 50 ma did output cause the band to move upwards, and even then the valve remained wide open with output at 50 ma. The edge of the band exactly followed suction pressure until further load changes caused it to continue upwards. The band will remain fixed at the point where its voltage is set until measurement again crosses into it. When this happens, depending on the rate at which it does so, one of two conditions can result: (1) if measurement is returning at a rate equal to, or slower than the reset rate, the band will follow it down to the set point and the valve will remain wide open; (2) if, however, pressure is falling faster than the reset rate, the valve will begin to throttle to keep pressure from falling further, and the controller will be performing its proper function. If the rate of fall is so great that overshoot does result, the voltage setting on the reset capacitor should be adjusted to raise the band further and start corrective action sooner.

Control of Station Starts-ups

There are a number of ways to control station start-up. The following illustrates one method for starting up a single-pump station, and one method for a multi-pump station.

Fig. 5 shows a control system with suction pressure, discharge pressure, and flow systems in the conventional automatic selecting arrangement.

The fifth component shown is a ramp generator (f) for slowly opening the control valve when starting up. It performs as follows:

1. The pump block valves are open.
2. The control valve is in the closed position, and held there by the function generator.
3. The pump is started and given time to get up to speed.
4. The function generator is started. This component has an output which is a ramp (or other characterized rising current), and is tied into the automatic selector system with the controllers.

As the system selects the *lowest signal* (assuming a current-to-open valve) the ramp generator has control because (a) the suction controller sees a high suction pressure and is trying to open the valve by a large signal; (b) the discharge controller sees a low discharge pressure and is trying to open the valve by a large signal; (c) the flow controller sees a low flow and is trying to open the value by a large signal; if any of these controllers were to open the valve, its throttling characteristics would produce a large flow early in its travel, and the station would likely shut down on low suction pressure. However, the function generator opens the valve slowly (compared to controller reset rate). Ultimately, one of the three controllers will take control, or the valve will go wide open. Thereafter the function generator (with its then high output) is out of the picture until returned to a low output again. The unit can be all solid state and can have a number of different output characteristics custom designed for any given valve.

Fig. 6 shows a multi-pump installation. While

arrangements like this one differ slightly on various pipelines, the point to be illustrated is common to most of them. No. 1 pump starts against a closed block valve but usually has insufficient power to cause a problem of low suction; otherwise a ramp generator can be used here, as above. When the second pump starts up, it is often difficult to open its block valve without shutting the station down on low suction. Several successful schemes use "anti-windup" circuitry in the suction controller so that, when the block valve on No. 2 pump discharge is cracked open, there will be early control action well before suction pressure reaches its normal set point.

Large Overrange

Overrange of measuring elements is one of the most serious instrumentation problems both manufacturers and pipeliners must face. Suction-pressure control is the real problem, of course, because it must be measurable in the range of 0 to 300 psi, but not show damage or zero shift at 750 psi. Most motion-type elements are capable of overrange of 50% over their span, which means that a larger span than might be otherwise desirable must be used.

One solution to this problem is a new force-balance pressure transmitter (Fig. 7) which can be overranged to 2000 psi with spans as low as 20 psi.

Telemetering and Remote Control

Electronic controllers can be programmed remotely by simple techniques.

Fig. 8 illustrates the M/62 electronic controller input circuit. The upper 10-50 ma signal and 100-ohm resistor give a measurement voltage of 1-5 v. The lower one gives a 1-5 *external* set-point voltage. The difference is the error signal. The 5.2 v is from an internal set-point voltage (Zener) source for setting the set point manually. The 65-v source is d-c power to the controller. The set-point signal thus can be telemetered or transmitted by radio and easily converted to 1 to 5 volts in the station. Note that it is a simple matter to switch the controller to its own set-point voltage source (A) if remote control is to be discontinued.

Conclusion

The same techniques are useful elsewhere in industry. *Automatic selection* can be useful to protect furnace linings, atomic reactors, and critical chemical reactions; *"anti-windup"* is a must in chemical batch processes; *function generators* are useful in any process where pump characteristics or heat-exchange coefficients must be accounted for. The systems described are available from at least three major instrument manufacturers in either pneumatic or electronic versions.

Acknowledgments

The author is grateful to Messrs. M. H. White and G. I. Bilyeu for their contributions to this effort.

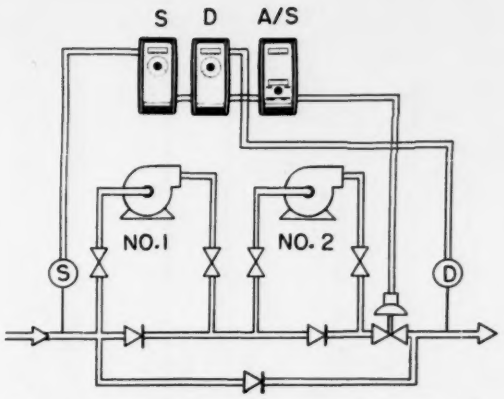


FIG. 6. MULTI-PUMP startup uses anti-windup circuitry for early control action to prevent fast-falling suction pressure from shutting station down. S is suction-pressure controller; D is discharge pressure controller.

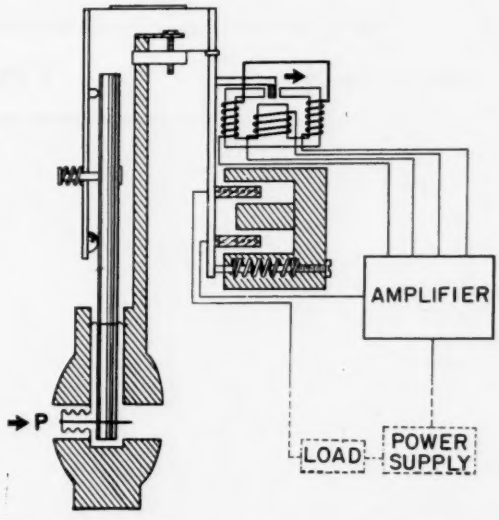


FIG. 7. PRINCIPLE of T/611 pressure transmitter.

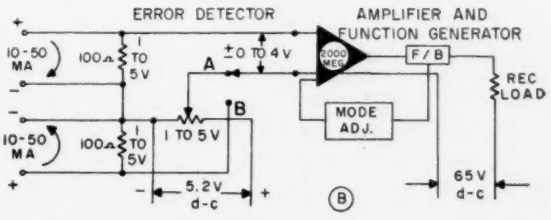
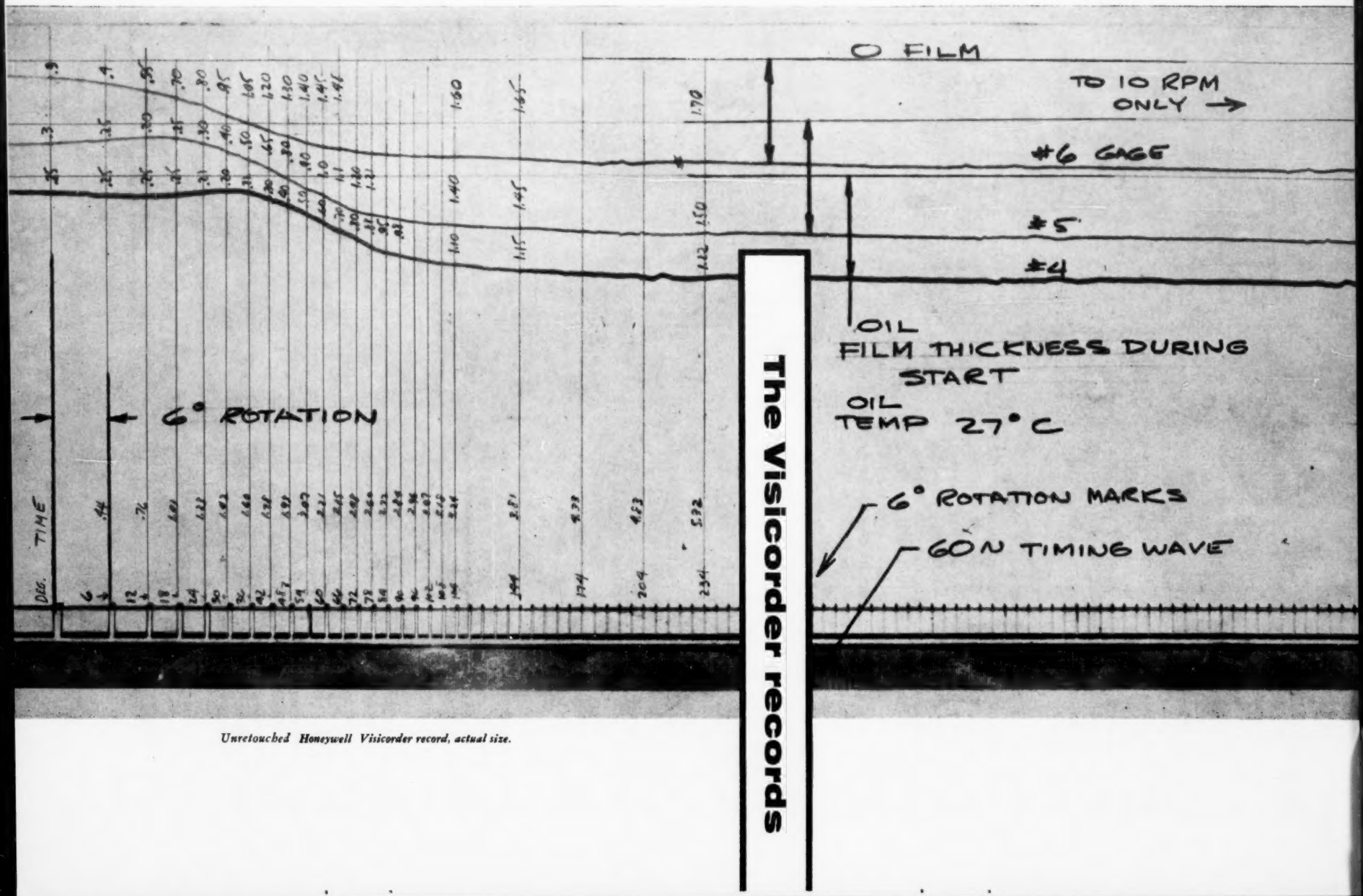


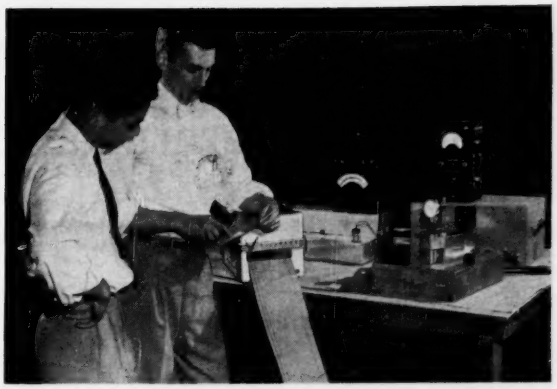
FIG. 8. SET-POINT switching. When switch is on A, set point (1-5v) is taken from internal 5.2-volt supply; when switch is on B, set point (1-5v) is established by 10-50-ma current from remote source.



Unretouched **Honeywell** *Visicorder record, actual size.*

The Westinghouse Electric Corp. used a Honeywell Model 906 Visicorder to make this directly-recorded chart of oil film thicknesses on the bearing pads of a 67,500 KW water-wheel generator supplied for Chief Joseph Dam at Bridgeport, Washington. In these tests, design engineers at Westinghouse wanted to ascertain bearing lubrication factors (oil film thicknesses) as a function of rotation and speed.

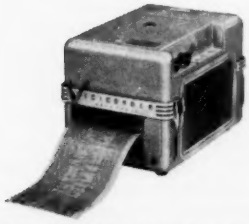
Bearings are designed so that as the water wheel generator comes up to speed, oil is carried mechanically over the bearings, and develops a film thickness that varies from .002 to .005 inches. Film thicknesses at the leading edge, center and trailing edge of one bearing pad were relayed by magnetic reluctance thickness gauges to the Visicorder. The thickness of the film at each of these locations as the bearing passed through each six degrees of rotation are represented by traces #6, 5, and 4 on the chart. Thicknesses as revealed by the test were proved to be close to the predicted design values.



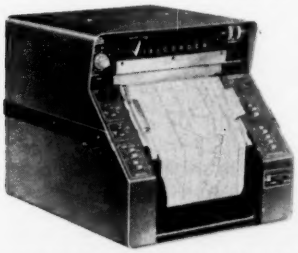
Stephen Chai and Glenn Cooper, Westinghouse development engineers, calibrate the Visicorder and other equipment used in water wheel generator tests.

The Visicorder was selected for these tests because, 1) high galvanometer sensitivities made the use of amplifiers unnecessary, 2) immediate readout was highly desirable and, 3) the portability and ruggedness of the instrument were helpful.

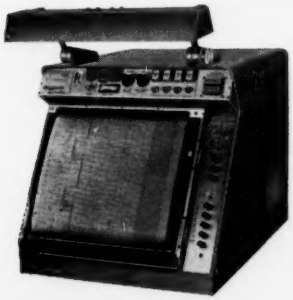
oil-film thicknesses



Recent Models of the 906 Visicorder incorporate time lines and grid lines and record up to 14 simultaneous channels of data.



The NEW Model 1108 Visicorder, with many automatic features and the convenience of pushbutton controls, is ideal for intermediate uses requiring up to 24 channels of data.



The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for recording as many as 36 channels of data.

The Honeywell Visicorder is the pioneer, completely proven, and unquestioned leader in the field of high-frequency, high-sensitivity, direct-recording ultra-violet oscillography. Here are some of the reasons why Visicorders provide the most accurate analog recordings available: constant flat response and sensitivity of galvanometers; grid-lines simultaneously recorded with traces to guarantee exact reference regardless of possible paper shift or shrinkage; flash-tube timing system for greater accuracy of time lines; superior optics for maximum linearity of traces.

No matter what field you are in . . . research, development, computing, rocketry, product design, control, nucleonics . . . the high-frequency (DC to 5000 cps) Visicorder oscillograph will save you time and money in data acquisition.

Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: Write for Bulletins 1108, 1012, and HC906B

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The Model 536: reliable, single-point controller gives you these options: ON-OFF or proportioning control... set-point adjustment in the instrument or remotely located... indication as well as control... expanded scales for fine temperature adjustment. And you pay only for the option you need. Capacity of 10 amp/110 VAC and 5 amp at 230 VAC.

The Model 561: single point indicator-controller designed for panel mounting. Panel button permits meter display of temperature set point. Control and indication circuits are independent. Mirror-backed scale prevents parallax, tilted glass cover reduces reflection. Option of either ON-OFF or proportioning control. 10 amp/110 VAC relay capacity... insensitive to voltage fluctuations.

The Model 580: multi-point indicator permits "flick of a switch" indication of 2 to 10 temperatures controlled by up to ten Model 536 controllers.

These are just the high spots. For *complete* details on this versatile Fenwal family, send for bulletin MC-190, "Smarter Looking Smarter Acting Electronic Temperature Controls." FENWAL INCORPORATED, 366 Pleasant Street, Ashland, Mass.

Another example of how **Fenwal** CONTROLS TEMPERATURE... PRECISELY

CIRCLE 66 ON READER-SERVICE CARD

TRANSDUCER EVALUATION

To compile a uniform set of definitions is a large order because most persons have strong feelings for definitions of the phenomena displayed by transducers. However, such definitions have evolved at Lockheed.

GEORGE VON VICK
Lockheed Missiles and Space Division

TABLE 1—COMPARISON OF VENDOR SPECS AND LMSD TESTS ON POTENTIOMETER TRANSDUCER

	Vendor Specs	LMSD Test Results
Full Scale Sensitivity	Not stated	91.5
Non-Linearity	1.0% (independent)	2.7% (terminal)
Hysteresis	0.7%	2.5%
Non Repeatability	1.0%	0.4%
Friction	Not stated	0.8%
Acceleration Error	Not stated	1.0% at 30g
Vibration Error	2.0% R.M.S. to 15g	3.2% for 15g
Shock Error	Not stated	0.8% for 50g
Sensitivity Shift with Temp.	3.4% for 200°F	6.0% for 200°
Zero Shift with Temp.	Not stated	8.0% for 200°

THE TRANSDUCER EVALUATION program at Lockheed Missiles and Space Division has disclosed that there are innumerable ways in presenting the characteristics of transducers. For example, a transducer manufacturer may describe the output of his instruments by any one of the following: full excursion, full range, full scale, full-scale sensitivity, sensitivity, span, active range, mechanical travel, electrical range, descriptive range, end setting or end point, output, percentage voltage ratio, etc. All these terms apply to the algebraic difference in electrical output between the maximum and minimum values of the forcing function over the range that the instrument is calibrated.

To compile a uniform set of definitions is a large order because most persons have strong feelings for definitions of the phenomena displayed by transducers. However, such definitions have evolved at Lockheed, as follows.

Non-Repeatability

Probably the most important criterion for a transducer is its repeatability.

Non-repeatability is a measure of the inability of an instrument to reproduce the same output while approaching the same calibration point from the same direction. It is the maximum divergence of a number of successive calibrations (usually 5), expressed as a percentage.

% Non-repeatability =
(Highest output minus lowest output reading at the same calibration point)(100) ÷ (Total Output)

In the original evaluation, the instrument is usually tapped or vibrated slightly to overcome some of the effects of friction. Evaluation tests performed on one pair of potentiometric transducers showed that an instrument which displayed 0.8% non-repeatability under normal evaluation procedures, increased to 6.2% non-repeatability under conditions of high vacuum and zero vibration.

Non-Linearity

Transducer manufacturers apply as many as twenty different methods for calculating non-linearity.

Non-linearity is the maximum divergence from a line drawn through the end points of the calibration curve, divided by total output.

The statements made in this paper do not necessarily represent approval by Lockheed Missiles and Space Division. This document is presented as an aid to the industry in the instrumentation field.

The maximum divergence in output is expressed as a percentage of total output.

% Non-linearity = (Maximum divergence in output) × (100) ÷ (Total Output)
Total Output = Output at maximum input point minus the output at minimum input point for rated input range

Assume we calculate the non-linearity of an instrument by the severe "least-squares" method, and arrive at a mean deviation of 3.4% non-linearity. By applying the "best-fit straight-line" method of interpretation, the same instrument could display as little as ⅛ the non-linearity displayed by the "least-squares" method.

Temperature Effects

Coefficient of thermal *sensitivity* is a measure of the effect of temperature on the sensitivity of a transducer. It is the difference in total outputs between the temperature and ambient calibrations for the particular temperature difference involved. This difference in total outputs is expressed as a percentage of the total output at ambient temperature.

% Coefficient of thermal sensitivity = (Total output at ambient temperatures minus the total output at either the hot or cold calibration, whichever is worst) × (100) ÷ (Total Output at Ambient)

Coefficient of thermal *zero shift* shift is the difference in output at zero stimulus for the particular transducer being evaluated, between the temperature and ambient calibrations for the particular difference involved. This difference in output is expressed as a percentage of the total output at the ambient temperature:

% Coefficient of thermal zero shift = (difference in output between the temperature and ambient calibration at zero stimulus)(100) ÷ (Total Output at Ambient Temperature)

The definitions listed are applicable in the evaluation of a transducer assuming that the following conditions existed during the initial calibration of an instrument:

1. The sensing element of a transducer was free to move in proportion to the applied stimulus over the full-rated range of the instrument without encountering mechanical stops.
2. The slope of the output vs stimulus curve did not change appreciably over the rated range of the instrument.
3. The transducer was excited with the rated input voltage and frequency for which it was designed.
4. The rated input stimulus was applied to the transducer except for cases where the rated range is difficult to obtain (i.e., absolute pressure transducers, temperature probes, and resistance thermometers).

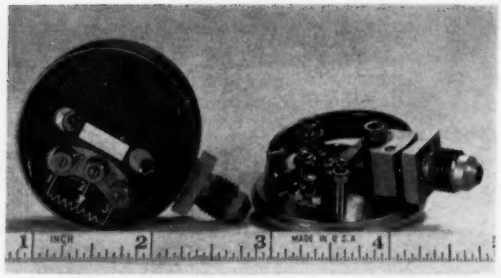

FIG. 1. MODIFICATION of guide pin and soldering technique improved this transducer.

Little consideration has been given to temperature effects of unbonded strain-gage transducers in a satellite environment. Under the conditions of high vacuum, the atmospheric heat sink is removed from the instrument and cooling must be accomplished by other temperature means or the transducer bridge will burn out by the I^2R heating effect of current. Under the conditions of space environment, cooling by convection cannot exist and we must rely on conduction for cooling. The application of "standard" absolute transducers is also ruled out under space probe conditions, because most absolute transducers are evacuated to 1×10^{-4} mm Hg on the reference side and to subject them to a condition of 1×10^{-14} mm Hg would result in large errors.

Hysteresis

Hysteresis is defined as the difference in output at given measurement points between the increasing and decreasing run of the initial calibration. The difference in output is expressed as a percentage of the total output.

% Hysteresis = (Maximum difference in output between the increasing and decreasing run of the initial calibration) × (100) ÷ (Total Output)

Hysteresis is an important factor because little can be done to reduce the hysteresis of an instrument without physically modifying the mechanical or electrical structure. Evaluation tests have disclosed that "exercising" an instrument—that is, applying a force function over the calibrated range of the instrument—tends to relieve stresses on the diaphragm and results in a more realistic indication of hysteresis. The initial functional calibration of a transducer that has been "on the shelf" for several months will display a much higher figure for non-repeatability, hysteresis, etc., than an identical instrument that has been "exercised."

Friction Effects

In space, pressure reduces from the normal 760 mm Hg to values ranging from 10^{-6} to 10^{-14} mm Hg. The effects of this reduction in pressure on

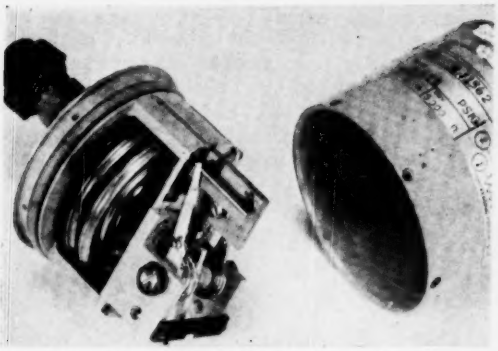

FIG. 2. THIS TRANSDUCER required wiper-arm modification.

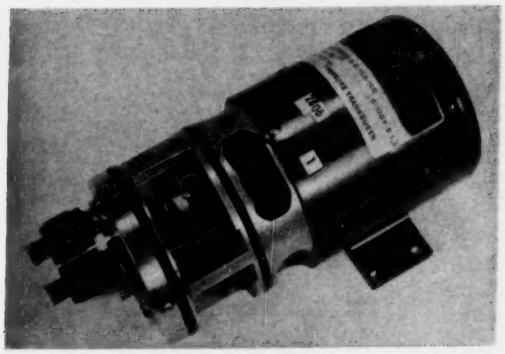

FIG. 3. MOUNTING SCREWS were modified in this pressure transducer.

friction is far from understood. It is now known that air retards the evaporation of an oil film from lubricated surfaces to a remarkable degree. It also affects the friction between dry metals by forming and maintaining lubrication oxide films over the metals. In transducers such as the potentiometric type, the loss of the oxide film could affect accuracies seriously.

Experience with moving mechanisms exposed to vacuum has shown that the operation of sliding metal surfaces in a vacuum results in large increases in friction. From this fundamental concept it would be expected that exposure to space vacuum can become a primary cause of failure in instruments which have been designed for low-altitude use.

Typical Test Procedures

The following general procedure was issued as a guide for the technicians involved in this work at Lockheed:

1. Identify transducer, room temperature, barometric pressure, time tests were begun, record all "time-out" and "breaks."
2. Commence testing with five ambient runs over the calibrated range of the instrument, recording the data points as outlined by the instrumentation engineer.
3. During test runs of increasing or decreasing force-function input, if an error is made, do not attempt to correct it, record the information noting that it is in error and continue.
4. Perform the ambient tests.
5. Elevated temperature run: Record time and barometric pressure; allow sufficient "soak" time at temperature.
6. Ambient run: Determine recovery after elevated temperature run.
7. Cold tests.
8. Five ambient calibrations: Perform as the initial calibrations. Record the data and submit.

Data Reduction

From the preceding data the following information is reduced by the evaluating engineer:

9. From item (1) corrections are made for barometric pressure and temperature; "down time" is recorded to compensate for unusual effects of excessive non-linearity and possible time peculiarities of the instrument tested.

10. From item (2) the non-linearity of the instrument is calculated as well as instrument sensitivity, and non-repeatability.

11. From items (5) and (7) the temperature sensitivity and zero shift is obtained.

12. From item (6) indicate the transducer recovery after application of temperature.

13. From item (8) the transducer repeatability is reduced, and a comparison is made with item (2).

Following the functional phase of evaluation, the transducer is subjected to environmental tests (shock, vibration, and acceleration). For this testing we have determined that commercial testing laboratories have been a satisfactory supplement to the testing facilities at Lockheed; however, very close liaison is necessary to assure the required accuracy. Additionally, it is necessary to take a calibration run between all environmental tests.

Table 1 shows typical results.

Evaluating Failures

Beneficial information becomes available from an evaluation program when an instrument fails outright. Such a failure is usually the result of poor design which would never come to light prior to the actual application of the instrument. Photographic evidence of instrument failure as a result of evaluation testing is reported to the manufacturer. In every case, a suitable modification was effected which produced a better instrument.

For example, the input port and bourdon tube of the transducer in Fig. 1 broke loose during acceleration. Modification of the guide pin and silver-soldering technique improved the reliability and performance of this instrument.

The transducer in Fig. 2 displayed erratic output due to oscillation of the wiper arm under high vibration. Modification of this arm produced a reliable instrument.

MACBETH ANNOUNCES

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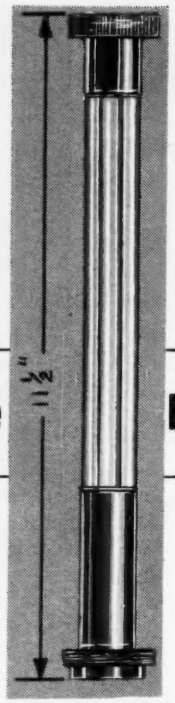
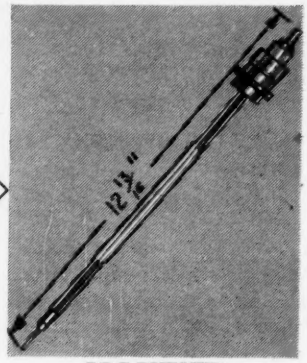
OSRAM XENON LAMP

with replaceable ARC BURNER



WATER JACKET

A milestone in the development of an already fine product was marked recently when Osram of West Germany announced its new replaceable arc burner. Henceforth its XBF Series Xenon high pressure long arc lamps will be made available with the replaceable burners.



ARC BURNER

Overall length of lamps with arc burner inserted in water jacket is 14"

The XBF-6000 series of lamps is now in two parts. The water jacket, shown is available in glass or quartz, (the latter for extra UV transmission). The arc burner, shown at right is available for AC or DC operation, both completely interchangeable in a glass or quartz water jacket. These new lamps will soon be available. For information on these new lamps, write to Macbeth Sales Corporation.

This replacement feature means that users can add to the already high performance, such features as:

(1) **Disposable burner - No returns for replacement when burned out, saving time and money.**
(2) **Simple replacement without tools.**
(3) **Ease of cleaning and maintenance.**

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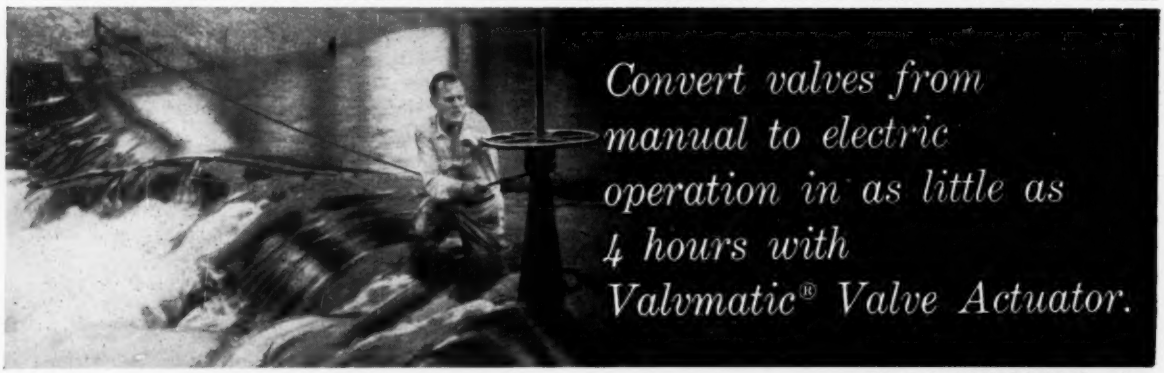

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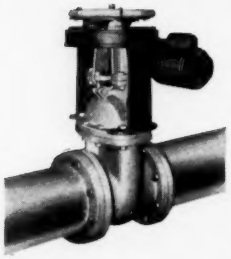

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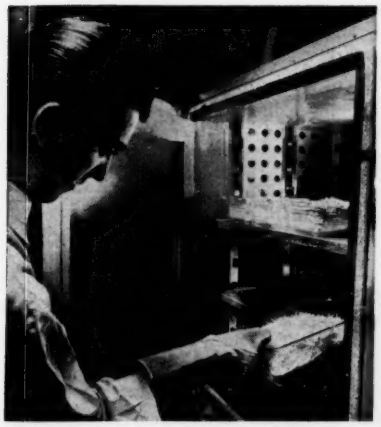
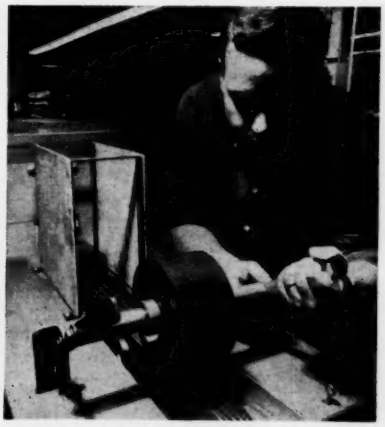


Insulators are stored in paraffin-sealed boxes, then baked to remove last trace of moisture. Assemblers wear gloves to prevent contamination of thermocouples.

Single-pass swaging of carefully-sized wire-insulator-sheath assembly produces no distortion in wire, insures greater accuracy and longer life.



Continuous hydrogen-annealing not only produces a ductile, brightly finished product, but also identifies improperly compacted material which is rejected during inspection

CIRCLE 69 ON READER-SERVICE CARD

Process Control Systems

FRED D. MARTON, Instruments Publishing Company

BACK-PRESSURE CONTROL UNIT USES LONG-STROKE ROLLING SEAL

A new valve control unit (Micro *Delta P** Controller) uses a long-stroke deep convolution diaphragm seal** for precise, yet rapid control of back pressure (upstream pressure). It uses a force-balance control system.

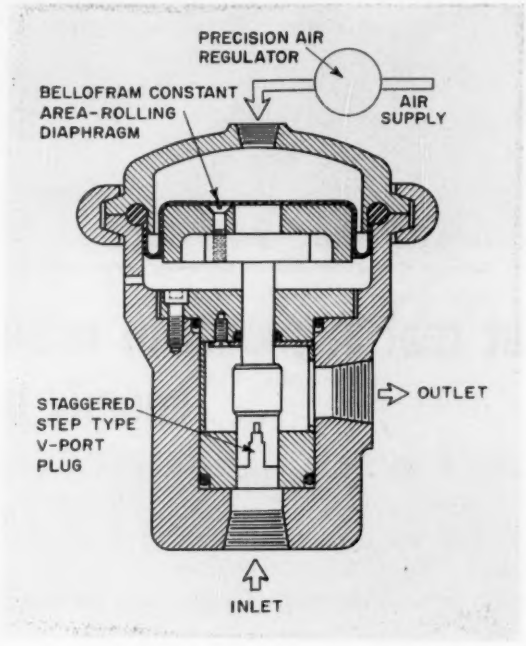
As it has no pilot valve, the response speed is high (1 second or less). As it functions as both controller and valve, it is an economic and simple unit with many applications.

Back-pressure control is defined as upstream pressure control, and the Micro Delta P qualifies for this adjective because it has the following principle of operation (Fig. 1):

The upstream pressure acting on the cross-sectional area of the plug is balanced by the fixed air pressure imposed on the constant area of the rolling diaphragm. Owing to the rolling-diaphragm principle, the plug can be moved through a long distance without altering the area of the diaphragm. This is in contrast with the conventional diaphragm wherein the diaphragm area changes with plug motion.

The outlet pressure has no effect on the balance because it acts on equal areas of the stem.

The ports are stepped to give a desired flow-lift characteristic for the particular application.



*Industrial Engineering Corp., Ky.
**Bellofram Corp., Mass.

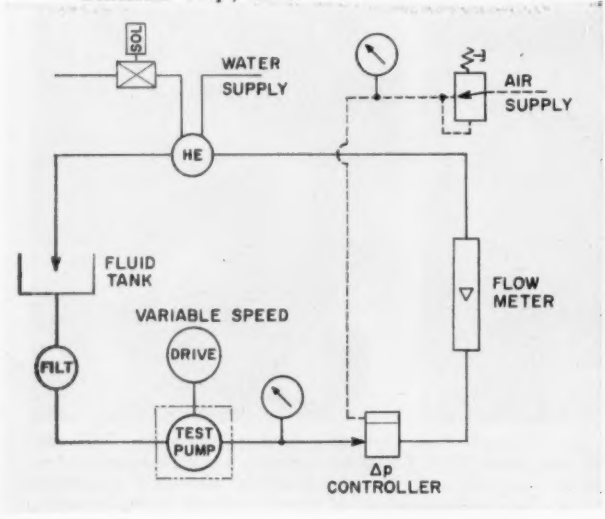


Fig. 2 shows use of this simple controller in a heat exchanger. As the downstream pressure is atmospheric, and as the controller maintains the upstream pressure at a fixed value, the flow (delta p) is thus maintained constant, despite variations in upstream pressure caused by level variations in the fluid tank.

Back-pressure control ratios of 18/1 are possible over large ranges of flow.

Repetitive control with an accuracy of ½% to 1% is possible because of the inherent low-hysteresis characteristics of the diaphragm seal and its minimum spring gradient. Cost also is reduced because of the use of a small diameter, long-stroke, diaphragm seal rather than a relatively large-diameter flat diaphragm. For example, it is possible to obtain a total stroke of nearly 5″ from a 3″ rolling-type seal, whereas a flat diaphragm would have to have a diameter several times that of the rolling seal for this stroke.

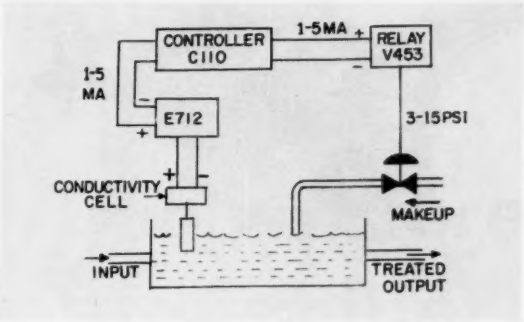
Source: Bellofram Corporation, Blanchard Rd., Burlington, Mass., and Industrial Engineering Corp., Louisville 8, Ky.

ALKALINITY CONTROL OF PROCESS WATER BY CONDUCTIVITY

Water in a processing plant has become a commodity which cannot be wasted. When contaminated by ionized chemicals or colloids it can cause damage such as uneven tinting in the textile dyeing industry, scaling in boilers, deposits on precision-fitting turbine blades, etc. When dumped into a river without processing, it can pollute the stream with harmful effects to humans, fish and wild life.

Conductivity measurement offers an inexpensive and efficient means for alkalinity control. The water is piped into an open tank and agitated by a stirrer. A conductivity cell (basically two platinum-plated electrodes to which a voltage is applied) sends a current through the water, and senses the conductivity, which varies as the ion concentration in the mixing tank varies.

Voltage variations in this system are sensed by a transmitting potentiometer (E712), producing a 1-to-5-ma d-c signal which is fed into a recording or indicating electronic controller. The resulting control signal is sent to a transducer that converts the electric signal to a pneumatic one, which in turn actuates a control valve for make-up. (An electropneumatic valve positioner on the valve can be used where such an accessory is warranted by size of valve or precise control requirements.) The make-up water allows



dilution of the alkaline process material to a degree where it is rendered harmless.

Applications of this simple circuit can be found in the paper and pulp industry, which uses large quantities of reconditioned water, in power generating plants, etc.

Equipment used: Transmitting potentiometer—Type E712; Controller—Type C110 recording or C120 indicating; electro-pneumatic relay—Type V453; valve—conventional single seat.

Source: Manning, Maxwell & Moore, Inc.; also Application Bulletin 7.2; also Robertshaw-Fulton Controls, Anaheim, Calif.

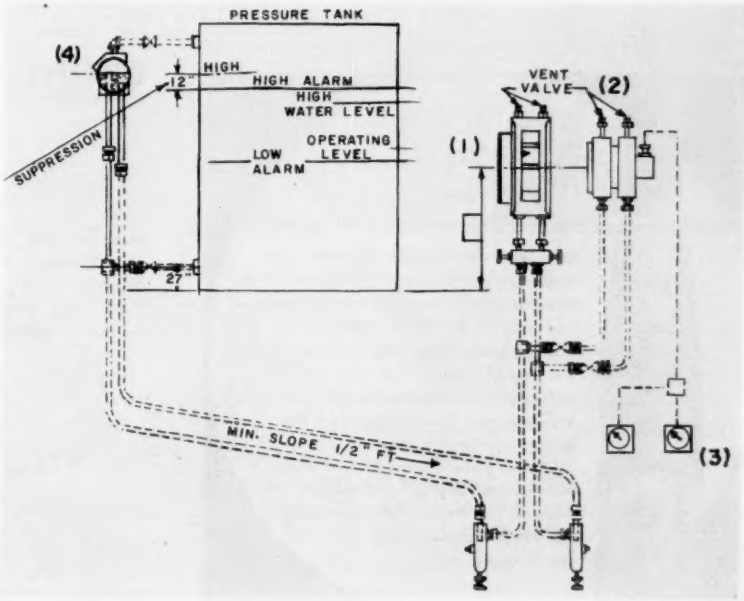
REMOTE INDICATION OF LEVEL IN DEAERATION FEED TANK

Water level in the various tanks aboard a ship requires remote indication on a centrally-located instrument panel, local indication near the tank, plus alarms for high and low conditions.

This system uses a hydraulic primary indicator, equipped with an electric-contact assembly to actuate visual and audible alarms, a differential pressure transducer, and voltmeters for secondary indication.

The indicator (1) is actuated by the differential pressure between constant head of water in chamber (4), located above high-water level, and variable-head connection in tank, located below low-water level. It contains a diaphragm assembly actuating the indicating pointer by magnetic coupling. Actuating diaphragm withstands full system overpressure. The indicator is fitted with a "control unit" containing switches and relays for actuating the alarms.

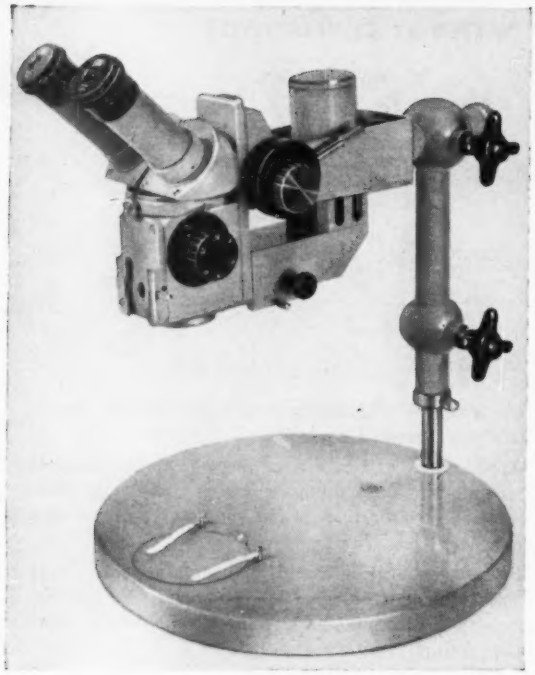
The differential-pressure transducer (2) is a diaphragm-actuated differential-transformer unit with 115 v (or 6.3 or 12.6 v) input voltage, and an output voltage range of 0 to 1 v, 0 to 2 v, or 0 to 10 v.



Receiving voltmeters (3) have a red scale which indicate low-level alarm at 41″, make-up on a white scale to 75″, surge volume on a green scale to 75″, spill on a white scale to 81″, and alarm on a red scale, when high level is reached.

Equipment used: (1) Indicator Fig. 4312 with Control Unit Fig. 4362E; (2) Differential-pressure Transmitter Fig. 4313; (3) Receiving Voltmeter; (4) Constant-head chamber assembly and dirt-leg assembly.

Source: Yarnall-Waring Co., Phila. 18; also Bulletin RI-1825.



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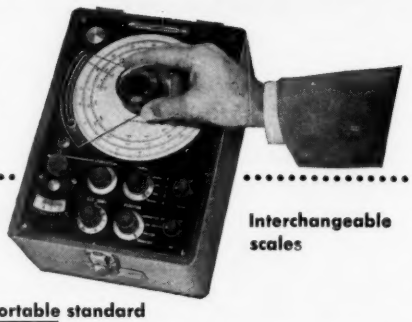

Interchangeable scales

A portable standard

The Pyrotest checks recorders, controllers and thermocouples . . . measures temperatures. It is a precision signal source, simulating thermocouple temperatures, for checking other potentiometers. Built-in "run up" permits checking of millivoltmeters.

19 different stock scales will fit one Pyrotest! Scales interchange in seconds. °F. or °C. calibrations for all types of thermocouples supplied. Scales directly read temperatures or millivolts.

Features include cold junction compensation, high accuracy, built-in standard cell. Request Bulletin 9B for complete specifications.

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Rugged, Sensitive Temperature Transmitter

Measuring Spans
of 50°, 100°, 200°, 300°, and 400°F, are easily set as required within over-all transmitter range of −100°F to +1000°F.

Stable Operation
Single lever, single pivot, force-balance system provides stable, friction-free operation.

Fast Response
Highly sensitive, low-volume, gas-filled bulb and minimum length capillary assure maximum speed of response.

High Accuracy
Full compensation for ambient temperatures and pressures helps maintain highest calibrated accuracy.

Low Cost Installation
Standard 3-15 psi output signal requires only low cost tubing for transmission to any recorder or controller.

. . . IMPROVES REMOTE CONTROL

There's no easier, simpler way to measure remote temperatures, over so wide a range, with such high sustained accuracy and speed, and at so low a cost!

The Foxboro Type 12A Pneumatic Temperature Transmitter converts temperature measurement to a linear output signal, which is transmitted to any standard 3-15 psi recorder or controller. Fully compensated for ambient temperatures and pressures, this rugged, highly responsive instrument performs outstandingly under the most severe conditions. And it's insensitive to mechanical vibration.

The transmitter weighs only 7 pounds with its integral mounting bracket. It can be mounted anywhere . . . in any position . . . even directly on a bulb well! The gasketed, weatherproof housing permits installation in any location.

Write for Bulletin 13-17. It explains fully why the Type 12A Temperature Transmitter gives better performance with lower installation and maintenance. **The Foxboro Company, 466 Norfolk St., Foxboro, Mass., U.S.A.**

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Pneumatic Temperature Transmission

CIRCLE 73 ON READER-SERVICE CARD

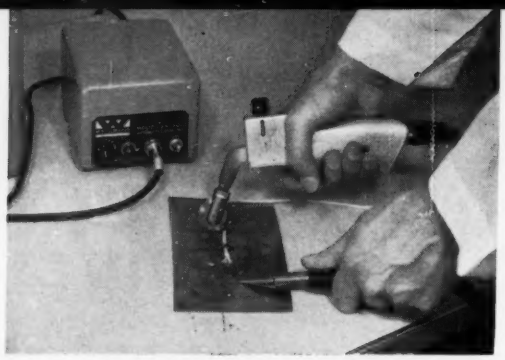


FIG. 1. HANDPIECE seam welder with adjustable pressure control rapidly welds tie-down bands for attaching lengthy thermocouple wire to large area of metal. Automatic timer fires welder continuously at pre-set rates between 57 to 120 welds per minute.

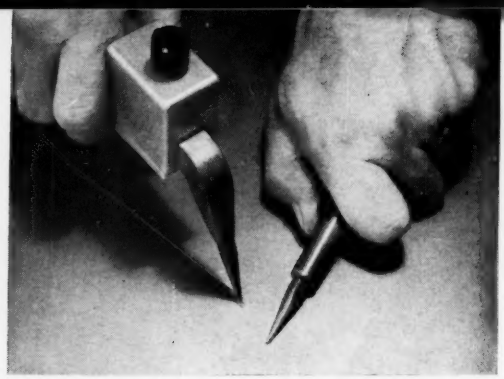


FIG. 2. PROBE-TYPE handpiece with saddle-grooved electrodes in position to weld Copper/Constantan 0.0020" thermocouple wire to 0.0060" mild steel. Resultant spotweld assumes characteristics of both parent metals.

Welded Thermocouple Junctions

Not only must the correct wire size and material combination be selected, along with proper insulation, but also the method of joining the wires (butt, cross-wire, coil-type sandwich) and welding technique.

HENRY C. JORDAN
Consultant
Unitek Corporation
Weldmatic Division

WELDED THERMOCOUPLE JUNCTIONS have many advantages, but diverse test and instrumentation needs may call for different thermocouple configurations.

It is always desirable to have the thermocouple junction remain intact at temperatures up to the melting point of the couple wires themselves. Hence resistance welding rather than soldering or brazing should be used in most cases.

Welding techniques include cross-wire, coil sandwich, solid wire, stranded wire, etc. Other factors include electrode shape, the welding-head pressure, and the watt-seconds of energy required for various wire combinations.

The design charts given classify some of the useful data derived from hundreds of practical thermocouple installations. Welder models A and B in the tables refer to Weldmatic Models 1015-E and 1023-24 (or equivalent) respectively. Data is included for Iron/Constantan, Chromel/Alumel, Copper/Constantan and Platinum—10% Rhodium/Platinum.

Response

One of the primary advantages of a resistance-welded junction is fast response time because the mass of the welded junction is comparatively small. No fluxes, solder, or fillers add to the mass.

Also advantageous is the ease with which the thermocouple can be welded to the surface where temperature is to be measured. As there is no "soft" metal to melt, the entire couple can be pinpoint-welded to an exact spot.

The Cross-Wire Weld

A *butt weld* makes an ideal thermocouple junction because a minimum amount of wire is used at the weld.

Another popular field installation thermocouple configuration is the *cross-wire* junction. Easy and quick to accomplish, the cross-wire weld, using solid wire, requires only that the insulation be removed from the wires at the point of intersection. The wires are crossed at the desired angle, then welded. Either the standard welding head or a tweezer-type handpiece can be used. Any excess wire is snipped off with scissors or diagonal cutters.

If stranded wire is used for the cross-wire weld, two requirements exist—(1) the strands of each thermocouple-wire material must be twisted tightly before they are crossed for welding; (2) both top and bottom electrodes should be grooved. Such grooves should be relieved in order to present a "saddle" type electrode. Such wire and electrode

Notes for Tables

RWMA #2 Electrodes can be used for the resistance welding of all materials and weld configurations presented.

(*) Total thickness of the completed cross-wire weld is approximately 1½ times the diameter of one of the wires used. Substantial welds can be made at lower power and pressure settings. The selection of a standard junction thickness for this Weld Guide was arbitrary.

(**) Some wire deformation is present. The total thickness, (*), was measured over the actual wire diameters rather than at the welded junction. The actual welded junction will measure less than 1½ times the diameter of one of the wires used in the welding process. In all cases, grooving of the electrodes will help to eliminate wire deformation.

(G) Electrodes are grooved but not relieved to have a saddle shape.

(GC) Electrodes are grooved and are relieved to have a saddle shape.

TABLE 1—IRON/CONSTANTAN, STRANDED, USING WELDING HEAD

Strands	B&S	Press. (lbs)	Watt-Sec	Electrode Shape (O.D.)	Welder
7/32	24	10.0	15.0	0.100"	A
7/26	18	23.0	78.0	0.125"	A
16/26	14	47.0	255.0	0.125"	B

TABLE 2—CHROMEL/ALUMEL, STRANDED, USING WELDING HEAD

Strands	B&S	Press. (lbs)	Watt-Sec	Electrode Shape (O.D.)	Welder
7/32	24	10.0	12.0	0.100"	A
7/26	18	22.0	78.0	0.125"	A
16/26	14	45.0	255.0	0.125"	B

TABLE 3—COPPER/CONSTANTAN, SOLID, COIL-TYPE SANDWICH WELD, USING WELDING HEAD

No. of Coils	B&S	Press. (lbs)	Watt-Sec	Electrode Shape (O.D.)	Welder
3	30	14.0	22.0	3/32" (G)	A
3	24	18.0	75.0	3/32"	B
2	22	22.0	110.0	3/32"	B
1.25	18	37.0	320.0	0.125" (G)	B

TABLE 4—COPPER/CONSTANTAN, STRANDED, COIL-TYPE SANDWICH WELD, USING WELDING HEAD AND WELDER B

No. of Coils	B&S	Press. (lbs)	Watt-Sec	Electrode Shape (O.D.)	Strands
1.5	20	25.0	170.0	0.125" (G)	7/28
1.0	18	40.0	320.0	0.150" (G)	7/26

TABLE 5—IRON/CONSTANTAN, SOLID, CROSS-WIRE WELD USING WELDING HEAD

B&S	Press. (lbs)	Watt-Sec	Electrode Shape (O.D.) and Flat)	Welder
36	1.8	0.80	3/32"	A
30	4.0	1.00	3/32"	A
24*	8.5	5.00	3/32"	A
18*	23.0	78.0	3/32"**	A
14*	47.0	255.0	3/32"**	B

TABLE 6—CHROMEL/ALUMEL, SOLID, CROSS-WIRE WELD USING WELDING HEAD

B&S	Press. (lbs)	Watt-Sec	Electrode (Flat)	Welder
36	1.8	0.8	3/32" O.D.	A
28*	5.0	1.9	3/32" O.D.	A
22*	10.5	11.0	3/32" O.D.	A
18*	21.5	75.0	3/32" O.D.**	A
14*	45.0	240.0	3/32" O.D.**	B

TABLE 7—PT-10% RH/PT, SOLID, CROSS-WIRE WELD USING WELDING HEAD

B&S	Press. (lbs)	Watt-Sec	Electrode Shape (O.D	Welder
36	1.5	3.0	3/32" Flat	A
30	4.0	9.0	3/32" Flat	A
24	6.5	35.0	3/32" (G)	A

TABLE 8—IRON/CONSTANTAN, SOLID CROSS-WIRE WELD USING TWEEZER HANDPIECE AND WELDER A

B&S	Press. (lbs)	Watt-Sec	Electrode Shape (Flat)
36	1.0	1.0	0.100" x 0.065"
30	4.0	3.5	0.100" x 0.065"
24*	6.5	25.0	0.100" x 0.065"
22*	7.0	75.0	0.100" x 0.065" (GC)

TABLE 9—CHROMEL/ALUMEL, SOLID, CROSS-WIRE WELD USING TWEEZER HANDPIECE AND WELDER A

B&S	Press. (lbs)	Watt-Sec	Electrode Shape (Flat)
36	1.0	1.0	0.100" x 0.065"
30	4.0	3.0	0.100" x 0.065"
24*	6.5	25.0	0.100" x 0.065"
22*	7.0	65.0	0.100" x 0.065" (GC)

TABLE 10—PT-10% RH/PT, SOLID, CROSS-WIRE WELD USING TWEEZER HANDPIECE AND WELDER A

B&S	Press. (lbs)	Watt-Sec	Electrode Shape (Flat)
36	1.5	3.0	0.100" x 0.065"
30	4.0	9.0	0.100" x 0.065"
24	6.5	35.0	0.100" x 0.065" (GC)

TABLE 11—IRON/CONSTANTAN, SOLID, CROSS-WIRE WELD USING HEAVY-DUTY TWEEZER HANDPIECE AND WELDER B**.

B&S	Press. (lbs)	Watt-Sec	Electrode Shape
20*	10.0	85.0	Std. (GC)
18*	15.5	170.0	Std. (GC)
16	24.0	420.0	Std. (G)

TABLE 12—CHROMEL/ALUMEL, SOLID, CROSS-WIRE WELD USING HEAVY-DUTY TWEEZER HANDPIECE AND WELDER B**.

B&S	Press. (lbs)	Watt-Sec	Electrode Shape
20*	10.0	90.0	Std. (GC)
18*	15.5	170.0	Std. (GC)
16	24.0	420.0	Std. (G)

preparation helps to contain all strands and to reduce the size of the finished junction.*

Coil-type Sandwich Weld

Another type of weld can be used for Copper/Constantan thermocouple wires, and requires only slightly more wire preparation than the cross-wire weld. To effect this weld, first the copper and constantan wires are stripped of all insulation. The constantan wire is then wrapped (coiled) tightly around the copper wire. One or two turns is usually enough. In this configuration, the higher-resistance wire (constantan) faces two low-resistance electrodes. Weld-area fusion is obtained by heating the outer, or coiled, constantan wire. This sandwich weld will be larger than a simple cross-wire weld. The finished junction can be trimmed, however, with diagonal cutters or other cutting tools.

The welding data on sandwich welds is based on some real fusion of the copper to the constantan, not just a crimping action. A crimping action, which includes melting of the constantan wire, and thus strong mechanical containing of the copper wire, can be made at much lower power settings than those listed.

One of the main advantages of the coil-type sandwich-weld configuration is that the comparatively high-resistance constantan wire is always on the outside of the junction, making it easier to re-weld the junction to other metals.

As with cross-wire welds stranded wire must be tightly twisted. Electrodes for the stranded sandwich weld are grooved, but not nearly so much relief for a saddle shape is necessary.

*Important note: all stranded wire sizes given in the charts are for wires of one thermocouple material, after they have been tightly-twisted but before they have been crossed and welded to the second thermocouple wire material.

Selecting Equipment

The selection of a welding head or handpiece for welding the thermocouple in place depends on the shape and dimensions of the metal to which the thermocouple must be welded. In general, the standard welding head will deliver more power at the weld area than either tweezer-type or probe-type handpieces (Fig. 1). However, many thermocouple applications require the use of one of the handpieces for accessibility.

When two sides of a work piece are exposed, a suitable welding head, tweezer-type handpiece or probe-type handpiece can be used to weld the fabricated thermocouple in place. Similarly, when either Iron/Constantan, Chromel/Alumel or Platinum-10% Rhodium/Platinum wires are to be welded, individually, one over the other, to a third metal with two sides exposed, the welding head, tweezer, or probe can be employed.

Probe-type handpieces are used when only one side of a work piece is exposed. An example would be the outside of a closed metal cylinder. These accessories are highly suitable for the resistance welding of thermocouple measuring junctions to such metal forms. A pressure-sensitive probe is available which will give more reproducible welds because of built-in pressure controls that need to be set only once for a selected welding pressure.

Performance Hints

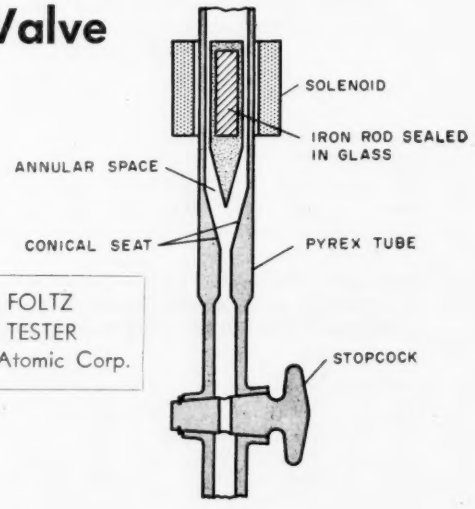
All of the thermocouple materials discussed can be resistance welded to comparatively high-resistance metals, including mild steels, stainless steels and nickel alloys. Excellent thermocouple junctions result. When the thermocouple materials listed are welded to those metals having comparatively low electrical resistance along with high thermal-conductivity characteristics, such as aluminum, copper and silver, special problems will occur.

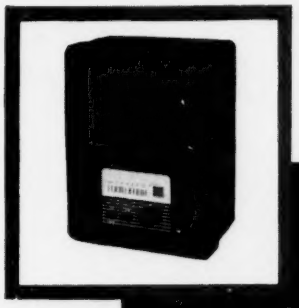
Corrosion Resistant Solenoid Valve

VALVE shown in figure can control the flow of liquids which would corrode valves made of customary materials of construction. The valve comprises a Pyrex tube, in which there is a conical seat and a stopcock; an iron rod is sealed in glass envelope, which is ground to fit the conical seat inside the tube. The tube is mounted in a vertical position. Energizing the solenoid lifts the plunger and liquid flows down through the annular space between the tube and the plunger. When the solenoid is de-energized, the weight of the plunger and the force of the liquid above causes the plunger to return to its original position on the valve seat and shut off the liquid flow.

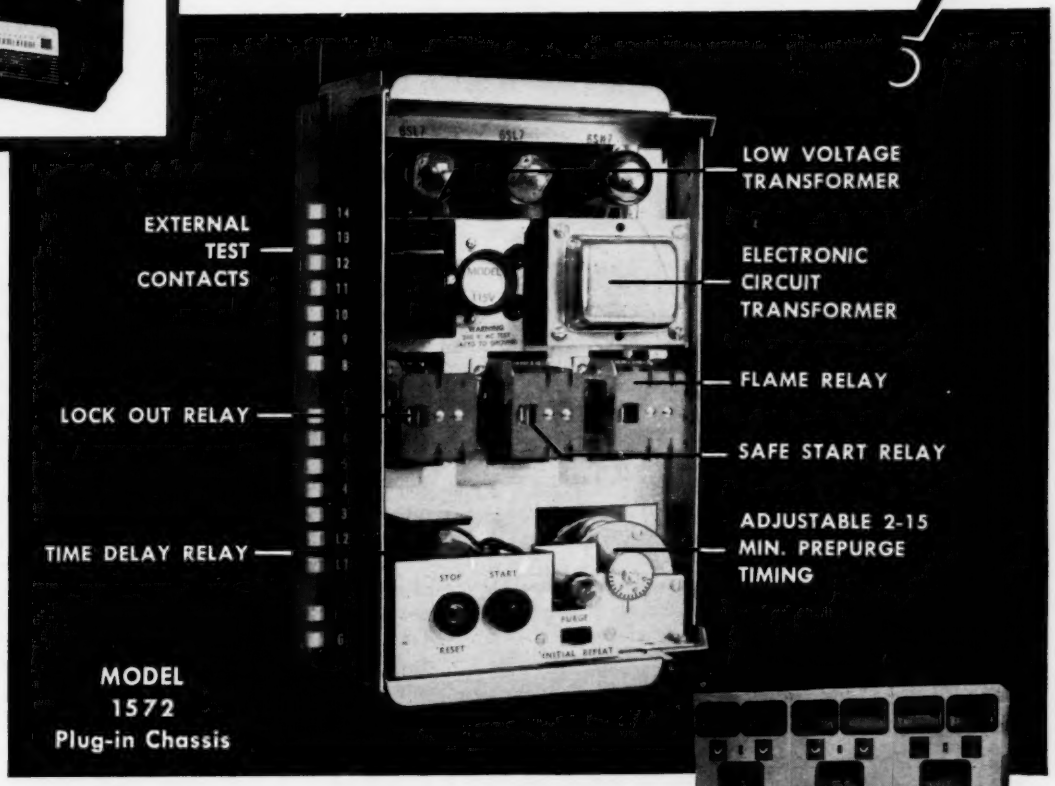
H. L. FOLTZ
M. E. TESTER
Goodyear Atomic Corp.

This work was performed under Contract AT-(33-2)-1 with the United States Atomic Energy Commission.





Fire when ready



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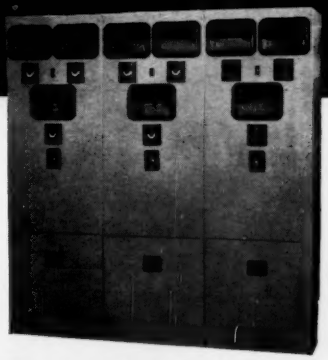

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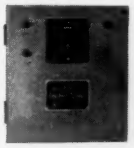

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CIRCLE 74 ON READER-SERVICE CARD

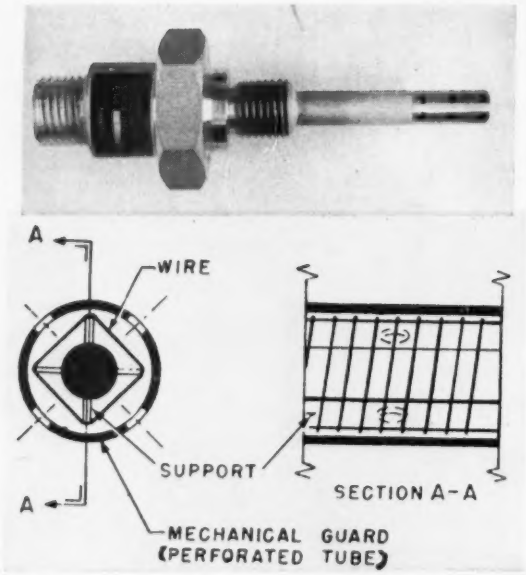

FIG. 1. PLATINUM wire temperature probe with exposed element. Detail shows wire coiled around mica cards. Measured fluids, entering through holes in guard tube, rapidly transfers heat to element wire, changes its resistance.

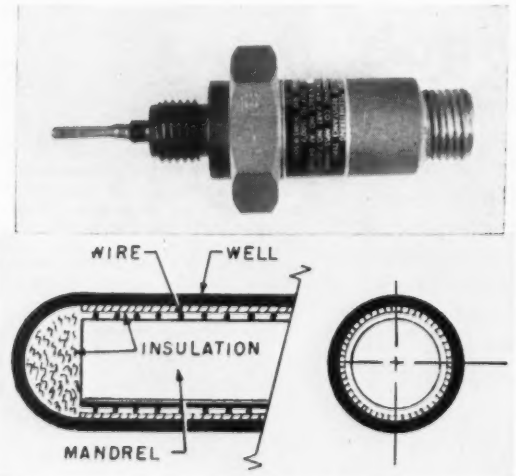

FIG. 2. RESISTANCE THERMOMETER with enclosed element. Thin probe well withstands high flow rates, high temperatures. Insulating film between well and element wire has high insulation resistance, is thin enough to permit rapid heat transfer from surrounding fluid to element.

RESISTANCE ELEMENTS

MISSILEBORNE TRANSDUCERS present many design problems. The environment to which they are exposed combines high vibration, ambient temperature extremes, large accelerations, humidity with ensuing moisture condensation, salt spray, and the possibility of rough handling. The media whose temperature must be measured include liquid gases, gases kept under extreme high pressures, various types of oils, and high-velocity exhaust gases. Rapid temperature fluctuations also must be observed.

Platinum resistance thermometry was selected because of its accuracy, repeatability and linearity.

Most transducers used are of the probe type. They are usually installed in a threaded boss on a duct, pipe or tank. The probe stem, containing the sensing element, protrudes into the fluid to be measured. The probe and the boss are made of steel. They are precision machined to provide a high-pressure seal in conjunction with a stainless-steel O-ring. Wide temperature extremes have no adverse effects on the all-metal seal. It withstands pressures in excess of 13,000 psia, even when helium is used as pressurizing medium.

The sensing element is a properly supported winding of pure platinum wire. As its inductance is in the microhenry range the winding need not be bifilar. It is usually a plain coil. The wire is drawn from the purest available platinum. Wire sizes between 0.6 and 3 mils diameter are those used most commonly. The turns are wound as evenly and as strain-free as possible. The finished winding is annealed at 500°C for 30 to 60 minutes to remove any residual strain. This annealing process also raises the temperature coefficient of resistivity of the wire ("alpha") to the value prescribed by the National Bureau of Standards for obtaining the maximum accuracy, repeatability, and shelf life without calibration change.

Exposed elements (Fig. 1) are used wherever possible to realize a fast response to a step change of temperature. These elements are wound over mica, platinum, or cramic supports. An extremely fast response is obtained from a winding over mica cards protruding radially from a rigid stem. A somewhat sturdier element utilizes cylindrically spaced platinum rods over which the wire is wound. Excellent performance, but a slightly longer response time, results from winding the element

FOR MISSILE TEMPERATURES

H. N. NORTON

Convair (Astronautics) Division
General Dynamics Corporation

on a threaded ceramic mandrel. The wire lies in the helical groove so that it remains below the mandrel surface.

A perforated tubular metal sheath protects the element from mechanical damage. Two or more elements can be wound on one stem if data must be provided to two isolated measuring systems simultaneously. The winding is exposed directly to the fluid whose temperature is being measured. With sufficiently large holes in the protective sheath, time constants of less than 50 milliseconds have been obtained. (The time constant refers to a resistance change equivalent to 63.2% of the total span of an applied step-function temperature change.)

When the measured fluid is not an electrical insulator, or when it could be detrimental to the platinum wire in other ways, an enclosed element (Fig. 2) is used.

Another successful type of enclosed element is a winding, completely embedded in a thin film of ceramic, wound around the outside of a metal tube. The expansion coefficients of tube, wire, and ceramic are closely matched so that thermal strains due to differential expansion between the two are avoided. Time constants for this type of probe are 0.1 to 0.2 second in moving liquids.

All probe designs described have passed vibration tests up to 35 g and 2,000 cps. As these tests are conducted with the instrument mounted only at its thread, the vibration amplitudes seen by the element vary from 50 to over 200 g, depending on stem length. The severity of the tests is increased further by performing them at the extreme temperature of the range the transducer is designed to measure.

Careful design for structural integrity of the supporting stem is essential to the reliability of the instruments. The stem portion also contains the connecting leads, which are platinum or other precious metal wire larger in diameter than the element wire. The leads are usually sealed in ceramic which, in turn, fits closely inside the metal-tube portion of the stem. A high-pressure ceramic-to-metal seal is made either in the thread area or throughout the supporting stem. Most resistance thermometer types used withstand a 12,000-psi burst pressure test.

The head of the instrument is the portion which remains external to the boss when the probe is installed. One piece of stainless-steel bar stock is machined to provide head, mounting, sealing surface, and a portion of the stem. Electrical connections on some transducers are made by means of a length of shielded high-temperature cable moisture sealed at its exit from the head. The standard configuration, however, uses a hermetic seal receptacle. The head is then completely sealed. A soft-solder covered "blow out hole" is usually provided in the side of the head wall to prevent a violent explosion in event leakage ever occurs in the ceramic probe-to-head seal.

Circuitry

Electrical requirements of the associated circuitry presently used require a resistance change from exactly 500 to 600 ohms in the thermometer for any given temperature range. This is achieved by using the correct amount of platinum wire in the element so that its resistance will change 100 ohms for a given range. A series resistor, located in the head, then is used to increase the total transducer resistance to 500 ohms at the lower range and point. The connection between element and series resistor is brought out to a separate pin in the 4-pin receptacle to provide a measurement of element

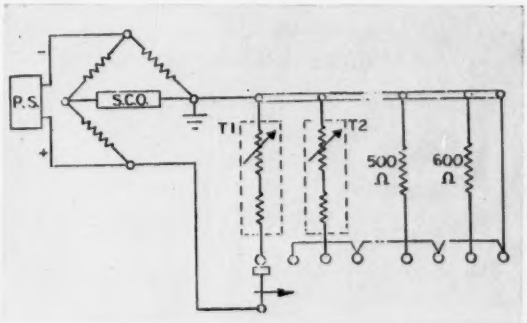

FIG. 3. SCHEMATIC of temperature measuring circuit shows thermometers T1 and T2 connected to commutator. Regulated power supply feeds bridge network. Unbalance voltage excites sub-carrier oscillator. Fixed resistors provide 0% and 100% calibration voltages.

resistance alone. (This is an occasional requirement when special calibrations are desired.)

The thermometer constitutes one arm of a Wheatstone bridge (Fig. 3) balanced for zero output voltage at 500-ohm transducer resistance and full scale sub-carrier oscillator excitation voltage (2.4 volts dc) at 600-ohm transducer resistance. A commutator is used to connect a number of transducers sequentially into the bridge network. This "temperature bridge" is self-calibrating by using some commutator segments to indicate zero and full scale. The calibration is accomplished by switching precision resistors of 500 and 600 ohms, respectively, into the bridge circuit when these segments are contacted by the commutator's wiper.

Intermediate values of temperature in any measuring range are obtained from the calibration curve of the particular transducer used. Each instrument is carefully calibrated by determining its resistance at various fixed temperature points. From these values the constants of the instrument are determined. These constants are inserted in the Callendar-Van Dusen equation which completely defines the resistance *vs* temperature characteristices of the platinum resistance thermometer between −182.97°C and +630.5°C. Sufficiently accurate empirical relationships are used to yield precise calibrations beyond these limits.

Environmental specifications include vibration levels, steady-state accelerations, and impact shock expected to be seen by the instrument, as well as salt spray, humidity and temperatures ambient around the head. Interchangeability tolerance is prescribed by accuracy requirements. Expressed in ± ohms this tolerance forms an error envelope along the theoretical calibration curve of all transducers carrying the same part number. They are then freely interchangeable within this tolerance. Tolerances from ± 1.0 to ±2.0 ohms usually are specified.

Probe length and element type are given by the nature of the fluid measured and its flow characteristics. Thus, the temperature of slowly moving gases is best measured by an open element approximately in the center of a duct or pipe, or several inches from the wall of a vessel or tank. Liquids whose flow is rapid usually call for a short probe with an enclosed element. A compromise between ideal probe length and expected vibration level is sometimes necessary.

The range of a platinum resistance thermometer, when used in the bridge circuit described, defines the amount of resistance in the element and therefore, the sensing element length. The element resistance is one of the limiting factors in temperature-transducer design because this resistance must always change by 100 ohms for full-scale output from the temperature bridge used. Thus, a transducer with a nominal range of 500°F to 1500°F contains an element with a resistance of 108 ohms at 500°F and 208 ohms at 1500°F. However, if the nominal range desired is −300°F to −270°F the element resistance is 338 ohms at −300°F and 438 ohms at −270°F. The former has a resistance of 71 ohms at room temperature, the latter a resistance of 1500 ohms. The larger amount of platinum required for narrow ranges increases the probe length as well as the cost. Temperatures which can be accurately measured by these instruments range from below −400°F to above +1500°F.

Platinum wire resistance thermometers and their associated circuitry have given satisfactory data during numerous missile flight and ground tests.

Pressure and Temperature Compensation of Flow Signal by Computer

BASIL MIKHALKIN

Bendix Computer Division

ONCE the information is in the computer the computation for pressure and temperature compensation is simple. Compensated flow = $K\sqrt{(\Delta P)(P)/T}$

The program steps are:

1. Multiply ΔP x P
2. (Divide by T): ΔP x P/T
3. Take the square root
4. Multiply by K
5. Type out compensated flow

Using Bendix Intercom 1000 programming, let us arbitrarily start the program at 10:00, the square root sub at 15:95.

	op code	Address	
10 00	51	10 50	Type in and store ΔP in 10:50
01	51	10 51	Type in and store P in 10:51
02	51	10 52	Type in and store T in 10:52
03	42	10 50	Copy ΔP into accumulator
04	44	10 51	Multiply Acc by P — Acc = P × ΔP
05	48	1052	Divide Acc by T: (P)(ΔP)/T
06	08	15 97	$\sqrt{P \times \Delta P/T}$
07	44	10:10	Multiply by scale factor
08	38	21 01	Type flow from accumulator
09	67	10 00	Halt
10			K (scale) factor)

Time required for one complete computation of compensated flow is 270 ms (computation time); computation time in standard machine language, rather than interpretive routine, would be 100 ms.

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CIRCLE 75 ON READER-SERVICE CARD

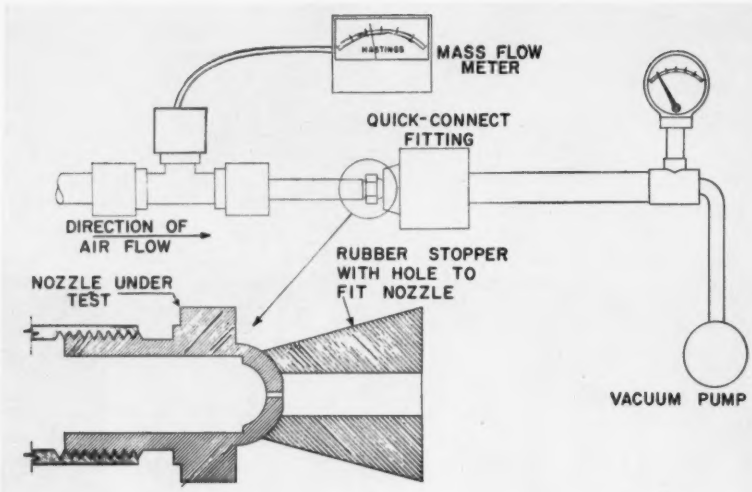


FIG. 1. ARRANGEMENT for testing small nozzles and orifices.

TESTING SMALL ORIFICES

A mass flowmeter can be used for rapid check of orifice diameter of small nozzles in production. Use of critical flow makes test independent of pressure downstream of orifice.

JAMES M. BENSON
and
CHARLES E. HAWK
Hastings-Raydist, Inc.

SMALL ORIFICES and nozzles of the types used in gas burners, oil burners, spray guns and expansion throttles of refrigeration machines are manufactured to tolerances that may be difficult to hold in routine production unless sample units are regularly inspected for accuracy of the drilled holes. Probably the most satisfactory method of inspecting these orifices is to establish a flow through the hole under a given set of conditions that are accuratey known, and to measure the resulting flow. The method described here makes use of a sensitive flowmeter comprising a compensated thermopile to measure the critical flow* of air through the nozzle. The air flow through the orifice can readily be established at the velocity of sound; this condition is easily reproduced with simple equipment that is well suited to routine testing. The method and equipment have proven particularly well adapted to the measurement of orifices having diameters ranging from 0.002" to 0.010", but are not limited to that range.

*Critical flow is flow that is independent of downstream pressure.

Critical Flow

When gas flows through a nozzle or orifice, the flow depends on the pressure differential across the orifice only up to a certain point. If the upstream pressure is held constant and the pressure at the discharge end is decreased, the flow of gas will increase up to a critical value. Beyond this point further decrease in the downstream pressure causes no further increase in flow. This is the *critical flow condition.* (It is related in a simple way to the velocity of sound in the gas, which in turn depends on the molecular weight and ratio of specific heats of the gas, as well as the temperature.)

When air flows through a nozzle, the critical condition is obtained if the upstream pressure is approximately two or more times the downstream pressure.[1] The equation for critical flow through a nozzle is:

$$q = CApK\sqrt{MU/T} \qquad (1)$$

where q is mass rate of flow of the gas; C is discharge coefficient; A is cross-sectional area of the nozzle throat; p is upstream static pressure of the gas; K is dimensional coefficient involving the

gas constant; M is molecular weight of the gas; T is absolute temperature of the gas upstream; and U is a constant that is characteristic of the gas equal to: $k\,[2/(k+1)]^s$, in which k is the ratio of specific heats (C_p/C_v) and $s = (k+1)/(k-1)$.

For air flow, this equation becomes:

$$q = 0.53\,CpA/\sqrt{T} \qquad (2)$$

where q is flow rate (lb/sec), C is discharge coefficient, p is pressure (psia), T is absolute temp (°R), and A is nozzle area (sq in).

A vacuum pump can be connected to the discharge end while the upstream end of the orifice is open to the atmosphere. The upstream pressure, p, is then barometric pressure; T is the absolute temperature of the atmospheric air entering the nozzle.

If the barometric pressure and the ambient temperature are constant, the flow (q) then depends only on C and A. Although much experimental data have been published for orifices having diameters of the order of 1″ and more, data for commonly used small orifices having diameters of the order of a few thousandths of an inch are more limited. However, some tests on several small orifices assembled from commercially available sapphire-cap bearing jewels ranging from 0.0024″ to 0.044″ diameter have been described.[2] On those tests the discharge was measured at a pressure ratio of approximately 3 to 1, assuring critical flow. Variations of 10% in the downstream pressure resulted in no measurable change in discharge. Variations in the upstream pressure had a linear effect on the discharge, in accordance with theory. Although the cap bearing jewel is not designed as a nozzle, the contour of the orifice does resemble that of a nozzle, and would be expected to have somewhat similar discharge characteristics.

Several "standard" sets of atmospheric conditions are in use. One standard, which has the advantage of being near the conditions usually found in a shop environment, specifies a temperature of 75°F (534.9°R) and a barometric pressure of 29.99″ Hg (14.73 psia). At these standard conditions, and for a nozzle coefficient of unity, the computed mass flow rate of air is 20.2 pounds per minute per square inch of nozzle area.

For actual nozzles made according to ASME standards, coefficients of between 0.92 and 0.97 are common. The coefficient for thin-edged orifices may be as low as 0.6.

Equation (2) can be rewritten as a function of the orifice diameter. The volume flow in cubic centimeters per minute of air at standard temperature and pressure becomes:

$$V = 6.0\ a^2$$

where a is the diameter in mils (0.001″).

Table 1 lists numerical values used in estimating the range of flowmeter suitable for testing various sizes of nozzles.

TABLE 1—EXPECTED VELOCITY FOR VARIOUS NOZZLE SIZES

a (mils)	V (cc/min)
1	6
2	24
4	96
8	384
16	1536
20	2400

Equipment and Procedure

A convenient arrangement for testing nozzles is shown in Fig. 1. The vacuum pump may be of several types. A water aspirator is satisfactory and inexpensive. Some models of diaphram vibrator pumps, such as used for paint sprays, also are satisfactory. A mechanical pump may be preferred for routine testing. The pump should have adequate pumping speed at the desired pressure of from 0.2 to 0.4 atmosphere. The smaller models of 1-stage or 2-stage vacuum pumps with ¼- to ⅓-hp motors are also satisfactory.

The suction line is provided with a quick-connect coupling at the point where the test nozzle is to be inserted. A compression-type seal, perhaps using a rubber O-ring, can be provided on the downstream side of the nozzle. This is the point at which leaks are most likely to be troublesome. The flow tube can be connected to the upstream side of the nozzle by another O-ring coupling, by a rubber tube, or by grommet. As there is no appreciable pressure drop across the flow tube, leaks are not likely to be troublesome on the upstream side of the nozzle. Note that leaks on the downstream side of the orifice are unimportant if they do not exceed the reserve capacity of the vacuum pump. This can be assured easily by observing the Bourdon-type vacuum gauge in the suction line.

On the upstream side of the flow tube, a simple air filter will insure against fine particles being drawn into the nozzle to cause clogging. The filter tip of a cigarette is convenient and suitable for this purpose.

When testing a large number of units it is advisable to have one nozzle with the desired characteristics. Others representing the high and low limits also may be desirable. Another sample having the same dimensions but without a hole in it also should be available. The standard nozzle can be tested occasionally as a check on the over-all performance of the set-up. The dummy can be inserted in the line as a check to insure against errors from leaks at the coupling.

Sensitivity

The sensitivity of the method can be computed from the known sensitivity of the flowmeter and the theoretical formula for flow through a nozzle. Consider a nozzle having a throat diameter of 0.005″. The critical flow will be approximately 150 cc/minute. A change of 3 cc per minute corresponds to a change of approximately 0.0001″ di-

ameter of the orifice, or 3%. This can be read easily on a 0-500 cc per minute meter scale; a 150-1000 cc per minute scale also is available for tests of larger nozzles.

Results

In a series of tests a number of commercially available nozzles was tested to see if they exhibited a definite value of critical flow which remained constant as the downstream pressure varied. A series of small orifices used in hand torches that burn propane gas was included. The flow through one sample having a bore of approximately 0.006″ was measured for several different pressures on the suction side. The flow was found to be 132 standard cc per minute, constant within ± 1% for all pressures from ½ to 1/10th atmosphere, the lowest pressure included in the tests. The theoretical flow through a nozzle having a throat diameter of 0.006″ is 216 cc per minute. The nozzle coefficient in this case is 132/216, or 0.61. The small nozzles used in these tests were more like a thick-plate orifice than a standard ASME nozzle.[3]

No attempt was made to examine the theory in detail for any particular shape of orifice or nozzle. It is sufficient for the present purpose that the results showed general agreement with theory.

A number of nozzles, all of the same production run, showed variations that were measured readily. Differences in flow among the various samples revealed variations in nozzle characteristics that correlated with variations in dimensions of the openings as measured with a micrometer microscope.

This flowmeter test method is fast and has the advantage of requiring a minimum of skill and concentration of the operator. The method also is adaptable to automatic controls when used with meter-relays or recorders to measure flow. An additional advantage over optical inspection is that the flowmeter test measures the nozzle discharge directly, rather than inferring it from a dimension that is difficult to determine, especially if the orifice is out-of-round.

References

1. Anon., "Fluid Meters, Their Theory and Application," 5th Ed, 1959, published by ASME, 29 W 39 St., N. Y. 18, N. Y., p 81f.
2. Anderson, J. W. and Friedman, "An Accurate Gas Measuring System for Laminar Flow Studies," *Review of Scientific Instruments* Vol. 20, No. 1, pp 61-66, Jan 1949.
3. Grace, H. P. and Lapple, C. E., "Discharge Coefficients of Small-Diameter Orifices and Flow Nozzles," *Trans. ASME*, Vol. 73, p 639, July 1951.

Digital Flow Control

HUGH O. JACOBSON, Librascope Div., General Precision, Inc.

DIGITAL control loop for flow is shown in Fig. 1. The flowmeter generates pulses at a rate proportional to the flow rate through the meter. Thus each pulse represents a certain volume of fluid delivered through the flowmeter. The oscillator paces the system by its output pulse rate, which acts as the set point. The frequency of the oscillator will control the flow rate. Many flows in a blending operation can be controlled at the correct ratio from the same oscillator.

The counter compares the *number* of pulses from the flowmeter to those from the oscillator. Should the number of flowmeter pulses exceed those from the oscillator, control action acts to close the valve, and vice versa. Over a period of time the actual volume passed is that represented by a pulse count. Thus, both flow rate and total volume are under simultaneous control. Both rate and volume must agree with that established by the oscillator for the system to be in equilibrium.

If the time switch is off for a while and the valve does not receive a new signal but stays at one setting for this time, the flow rate may drift. When the switch is closed, the valve will move to correct the flow and will continue to correct until the total volume requested during the time the switch was off is realized. The register acts as a memory device for the set point of valve position.

The limit of accuracy for the system, with respect to total volume of flow, is precisely that of the digital flowmeter. The counter does not affect the accuracy of the system. It only maintains a comparison between a requested number of pulses and the actual pulses delivered by the flowmeter.

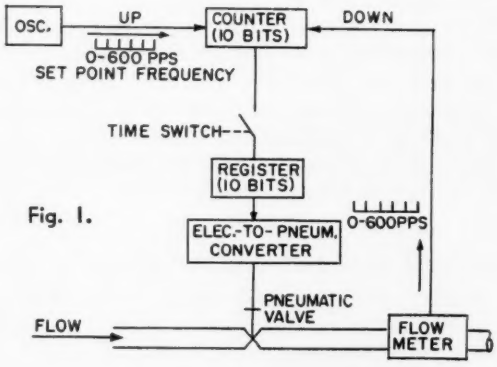
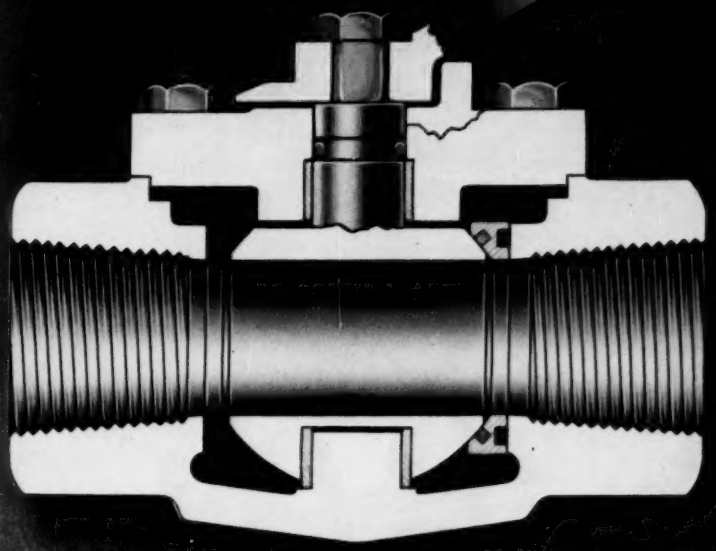


Fig. 1.

CIRCLE 76 ON READER-SERVICE CARD →

....how can 1 valve replace 3?



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Company name _____

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2. Reduce inventory costs . . . *by standardizing on one type valve for all applications requiring gates, globes, or plugs.*

3. Reduce maintenance costs . . . *the FLO•BALL high reliability means less maintenance . . . no lubrication, no freezing, positive sealing. The top loading and replaceable seat reduces overhaul and start-up costs.*

Principles of Operation

In the bearing-fixed FLO•BALL valve all pressure forces exerted on the ball are transmitted to low-friction bearings. The pressure balanced seat results in a sealing force which is designed to insure positive sealing without seat distortion, and to minimize seat-resisting frictional forces. The combination of these low frictional forces accounts for the extremely low operating torque.

FLO•BALL VALVE
Fixes ball • Floats seat

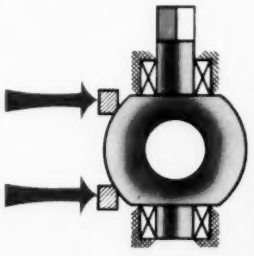

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FIG. 1. NEW AVCO R.A.D. Laboratories.

Instruments Are Affected By

VIBRATIONAL ENVIRONMENT

Increase in use of indicating instruments in newly-constructed laboratories points up a neglected problem of great importance—the deleterious effect of vibration upon the operation and precision of the instrumentation.

C. E. WHITE
AVCO
Research and Advanced Development Div.
Wilmington, Mass.

SUCCESSFUL USE of indicating instruments is predicated upon a vibration-free support plane. Since few such perfect, practical, vibration-free support areas exist in the laboratories of today, instrumentation must cope with a minimum, irreducible amount of vibration. The problem is—*what amount of vibration is responsible for measurable distortion and resultant inaccuracy in the visual or transcribed output of indicating mechanisms?*

Manufacturers of measuring equipment seemingly are not concerned with this problem. They assume that the consumer will take precautions in mounting instrumentation equal to those employed in the manufacturer's development area. However, *the manufacturer does not convey to the consumer any data on what constitutes the ideal environment.*

Also, what is the situation encountered by the designing engineer or architects who are required to supply plans for the containment of personnel and equipment? How certainly can they supply the newly-organized or recently-moved laboratory with a working area suitable to house sensitive electronic or optical microscopes, surface finish indicators, auto-collimators, reflecting galvanometers, micro-balances, etc? Without knowledge of the minimum allowable vibrational environment for each type instrument, there is no assurance. Yet details and specifications of such minimum vibrational environment are practically impossible to obtain from the typical manufacturer, and every laboratory suffers the effects of vibration —even after extreme precautions have been taken in planning and construction.

Technical personnel acquainted with these fundamental problems of vibration attempt to plan building areas in such a manner that sensitive equipment is located in specially strengthened or isolated areas. Perhaps an attempt is made to stipulate in planning that vibration will be held to definite values within specified frequency ranges. In establishing practical values, the manufacturer could be of inestimable aid if he were to supply some figures for vibrational environment considered satisfactory for operation of his instrumentation. It has been the writer's experience, however, that to obtain such figures is an impossibility. This experience is not unique, since a careful check of various laboratories throughout the country has revealed how little investigation has been made of the subject.

This is a statement of an important problem and an expressed wish that laboratories specializing in vibrational studies devote some time to a study of the deleterious effect of vibration upon indicating devices. This could be followed by the assembly of empirical data useful to the design activities responsible for construction of laboratories, or the approval inspection thereof. Such data would free design people from the necessity of attempting to design vibration-free structures, which is a practical impossibility in industrial building. Furthermore, it would produce a figure to be presented to inspection activities

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FIG. 2. MICROHARDNESS tester in use.

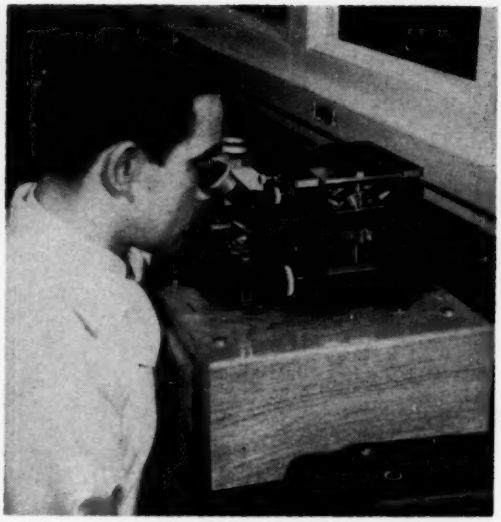

FIG. 3. INTERFERENCE microscope determining scratch depth.

in construction work by which the builders work could be verified and approved.

A typical example is to be found in Armed Forces Transportable calibration centers usually established in large vans. Each van is required to be air conditioned. The presence of a three-ton refrigerator unit within the physical confines of the van is sufficient to cause occasional aberrations in reflecting galvanometers, sensitive working standard dynamometers, standard barometers, etc. Because of the flexibility of the van structure, isolation from the vibration is extremely difficult.

Another typical example was encountered when microscopic inspection was required in a machining area. Repeated complaints were received that photographic studies of finished surfaces could not be made satisfactorily. A check of the location disclosed severe disturbances averaging 900 microinches displacement peak-to-peak, at approximately 22 cps. Isolation and other corrective measures reduced vibration to 100 microinches. Successful photographic studies were then feasible.

Because of its greater sensitivity, a newly organized laboratory purchased and installed a foreign-made electron microscope in preference to an American unit. When it was discovered that operation of the unit at the increased sensitivity was impossible because of blurred images, our activity was contacted. Analysis of the physical area was made and vibrational disturbances of approximately 12 cps and averaging 940 microinches amplitude were disclosed. It was necessary to relocate the microscope in another section of the room, and to take corrective measures in several parts of the building before normal operation of the unit could be restored. Presently, average disturbance is approximately 40 microinches.

The experiences of the writer during the course of planning, inspecting, occupying and reoccupying new laboratory facilities serve to focus attention upon the pressing need for empirical data to enable an engineer to forestall trouble when relocating laboratories.

Measurement Philosophy

Fundamentals of measurement precision as affected by physical conditions include the following factors:

1. Precision is defined as the repeatability of a measurement.

2. Phenomena such as thickness of line width, parallax, variability of estimation of pointer or needle position, etc., contribute to observer error.

3. An average operator is able to estimate the position of pointers to one-tenth of a scale division[1].

4. There is an optimum choice of the line width denoting a scale division. This was determined by Backstrom[1] and reconfirmed by Harris[2] to be a line width equivalent to one-tenth of the space between divisions.

The foregoing gives some boundaries affecting an expression of measurement-error threshold. For example, when using pointer-type instruments we can state that any environment producing a deviation equivalent to one-tenth of a scale division has exceeded the threshold of error determination. For this reason it is an undesirable environment and must be eliminated if confidence level in the measurements is to be maintained to a high degree[3].

Case Histories

The reestablishment of several laboratories in new locations brought with it unexpected headaches be-

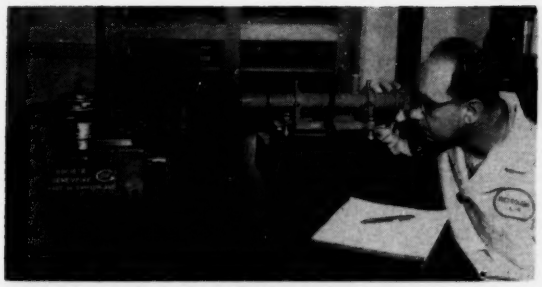

FIG. 4. AUTO-COLLIMATOR calibrating optical dividing table.

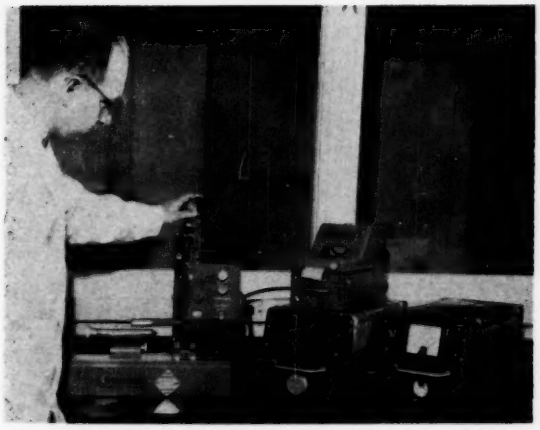

FIG. 5. TALYSURF measuring surface finish.

cause of severe building vibration.* A brief description of instrumentation affected and the fundamental operational principles follows:

LABORATORY NO. 1

Tukon Microhardness Tester (Fig. 2)—a force instrument thrusting a diamond ball point with a controllable loading into a material to be tested. An attached calibrated microscope views the resultant depression and gauges the depth.

Vibrational disturbances recorded in the area averaged 595 microinches at a fundamental frequency of 10 cps. The instrument could not be employed with loading less than 100 grams. Test samples had been ruined and a diamond stylus damaged. After corrective action was taken within the building, vibration was reduced to 32 microinches average and the instrument was useable with loading as low as 10 grams.

LABORATORY NO. 2

Sartorius-Werke Analytical Balance—a symmetrical beam unit employing built in weights with a resolution of 10 micrograms.

Initial vibrational disturbances averaged 65 microinches. The zero-shift or error introduced into the instrument was too large for satisfactory use with small masses. By relocating the unit, installing isolation mounting, and applying corrective actions elsewhere in the building, average disturbance was reduced to 16 microinches and the utilization of the scale extended to small masses.

LABORATORY NO. 3

Carl Zeiss Interference Microscope (Fig. 3)—a surface analyzing instrument, employing a monochromatic light source shining upon a test surface which, when magnified, presents a "contour line" representation through principles of light interference. It is capable of measuring surface depressions over a range of 1.2 to 79 microinches. The mounting of microscope, light source and sample is of an integral nature.

This unit was subjected to building disturbances averaging 8.2 microinches, resulting in blurred fringe line patterns. The instrument was unable to be used except during minimum disturbance intervals.

Watts Microptic Auto-Collimator (Fig. 4)—a dual unit assembly physically displaced, comprising a telescope-type viewing unit with associated double cross-hairs serving as a reference frame, viewing optical elements, and a plane surface mirror unit. This instrument has a resolution of 0.1 second of arc.

This unit was subjected to disturbances averaging 6.8 microinches, resulting in blurred images of the reflected cross-hairs. The blurring was equivalent approximately to three times the width of the cross-hair image. The unit is not employed during periods of vibration exceeding 4 microinches.

Taylor-Hobson "Talysurf" (Fig. 5)—an electronic-mechanical surface-measuring unit of rigid assembly with a test platform mounted on a lapped guide rail, and a sensitive feeler capable of being depressed. The depressing action is read out on a meter or on a recording graph in terms of microinch variations.

This instrument was subjected to average disturbances of 9.3 microinches. Since the unit is capable of measuring surface irregularities as minute as 2.0 microinches, reduction in functioning was inevitable under the environment encountered. The instrument presently is employed during periods of comparative quiet only if more refined measurements are required.

LABORATORY NO. 4

Leeds & Northrup Reflecting Galvanometer (Fig. 6)—essentially a tiny mirror suspended by fine wires, subjected to electrical currents; displacement is measured by the movement of a reflected light beam on a large horizontal scale physically displaced at least one meter.

A disturbance of 8.9 microinches was observed to cause a light beam reflection of 1 millimeter. The nature of the deflection was such as to introduce difficulty in null balancing, thereby reducing usefulness of the instrument during disturbance periods. Reloca-

*Note—All vibrational disturbances are expressed in microinches vertical displacement, peak-to-peak.

tion to be near pillars reduced disturbances to 2.5 microinches average, with a corresponding improvement in scale display.

LABORATORY NO. 5

Haas Standard Barometer (Fig. 7)—fundamentally a vertical glass tube, mercury filled, equipped with magnifier to read out height of meniscus. This instrument has a precision of 0.004".

Original disturbance measurements averaged as much as 54 microinches, limiting use of the barometers because of meniscus fluctuation. When the disturbances were reduced to approximately 20 microinches average, satisfactory readout was obtainable.

Mettler Analytical Balance (Fig. 8)—a single-pan balance employing the constant load principle, and having a resolution of 0.05 milligram.

This unit, although exposed only to an average disturbance of 8.7 microinches, could not be utilized to fullest accuracy. The disturbance mentioned was determined to cause an error of 0.2 milligram. As the capacity of the instrument is 200 grams, and as it has a precision of 0.05 milligram over the full range, it is readily apparent that accurate measurements of the smaller masses are not practicable except in periods of least disturbance.

Discussion

Some studies of cause and effect have been carried out. The Talysurf lends itself readily to the determination of transmissability of vibration. Our results indicate a vibration transmission factor of 0.15 microinch/1-microinch disturbance. Similar studies with the L&N Galvanometer gave a transmission factor of 0.11 millimeter/1-microinch disturbance when employed with a scale at two meters distance. Investigation of the performance of the Gram-Atic Balance established a zero-shift of 23 micrograms/1-microinch disturbance.

Factors such as those presented are useful only under environmental conditions similar to those in the laboratories examined. However, they do present some relationship between disturbance and error introduced. We are interested in learning of the experiences of other laboratories and would like to compare results of transmissability factors for identical equipment.

Acknowledgement

The data presented in this paper were obtained through the efforts of AVCO's Instrumentation Support Group. The author appreciates the interest of Messrs. Childs, Urbonas, Vilnit and the associated supervisors of the several Laboratories concerned. From its start as a nuisance problem to our present official concern in the matter has taken just over one year, but in that time our people have developed a growing awareness of an every-day problem too often recognized but not analyzed. A continuing study of the problem with its interesting connotations will be maintained.

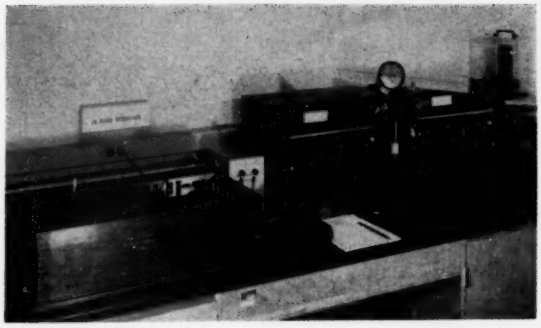

FIG. 6. SENSITIVE null-balancing with the reflecting galvanometer.

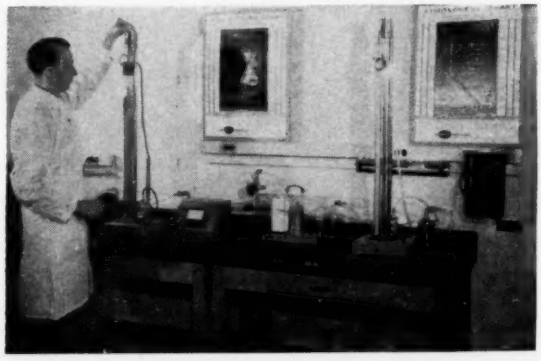

FIG. 7. ADJUSTING a standard barometer.

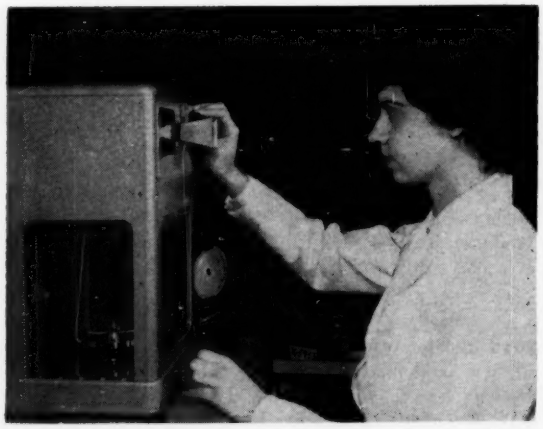

FIG. 8. METTLER analytical balance calibrating class "S" weights.

References

1. Bäckström, Vol. 50, 52, *Zeits fur Instrumentenk*, 1932

2. Harris, *Electrical Measurements*, Wiley, 1956

3. White, Standards—Stepchild in the Laboratory, *Journal of Audio Engineering Society*, (Vol. 7 No. 2, April, 1959.)

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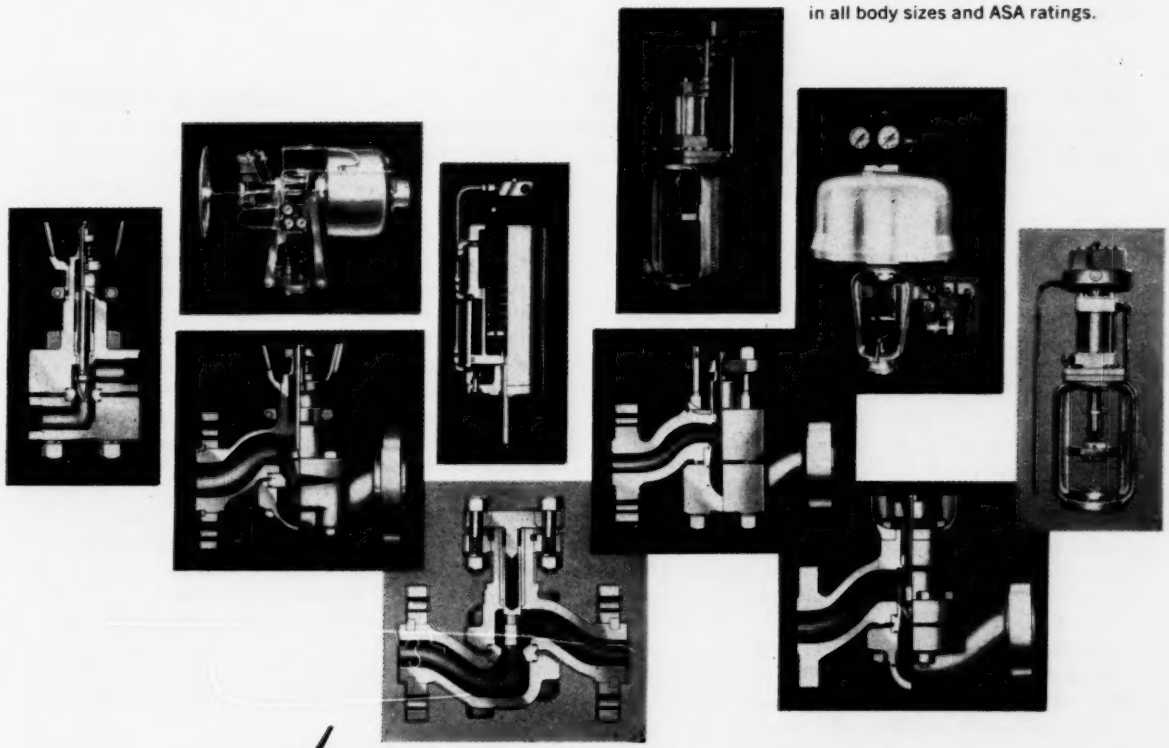

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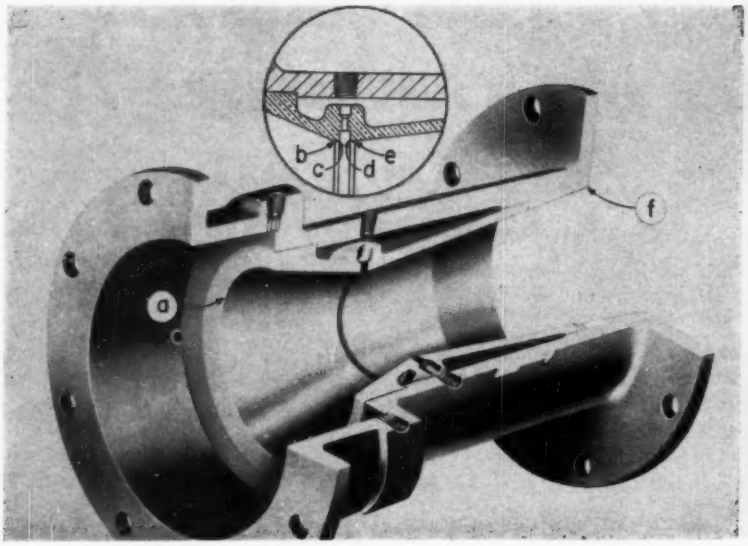


FIG. 1. DALL FLOW tube made of cast iron with a bronze throat.

The Dall Flow Tube

The Dall flow tube combines the high differential of an orifice with the low loss of a Venturi. The result is the best recovery factor expressed in % of differential. Also included is a presentation of accuracy measurement based on statistical techniques.

RODGER B. DOWDELL
Builders-Providence Inc.

THE DALL FLOW TUBE was invented in England by Mr. H. E. Dall, chief hydraulic engineer for George Kent, Ltd., about 1950. It operates like the conventional Venturi tube, but is much shorter and has considerably less pressure loss (expressed in % of differential). At the present time there are three basic designs of this Dall flow tube.

The model shown in Fig. 1 is cast iron with a bronze throat section and is used primarily for measuring water flow in municipal service where the tube is buried in the ground and life requirements are a half century or more. This unit is between 1½ and 2 pipe diameters in length. It has the same internal contour as the insert Dall tube (Fig. 2) except that the upstream pressure is taken at the upstream dam instead of behind the upstream cone. This change in location of the upstream tap has no noticeable effect on performance.

The fluid, flowing from left to right in Fig. 1, first strikes an abrupt reduction in area called the upstream dam (point a). It then passes through a converging cone, across the slotted throat, and then diverges out in angles considerably steeper than that of the conventional Venturi. At the exit point (f) there is an abrupt increase in area.

If we examine the slotted throat section (inset circle in Fig. 1), the throat slot is preceded and followed by a small cylindrical section. In passing through the throat, the flow strikes a corner at b, c, d, and e, which should be conducive to a high loss—but isn't.

Fig. 2 shows the Plastic Insert Dall Tube. This is the most versatile design and can be used to meter most corrosive fluids in process applications. It is constructed from a bronze or stainless-steel ring inserted into a mild-steel flange. The upstream and downstream cones are made from epoxy or polyester resin, reinforced with fiberglass. It is held and centered by bolting the carbon-steel flange between two standard flanges.

The high-pressure tap measures the pressure in the annular space outside the upstream cone. The low-pressure tap connects to the throat slot.

A third model, called the welded insert model, is primarily for high-pressure or high-temperature work.

Presented at the Fourth International Automation Exposition, Coliseum, New York City.

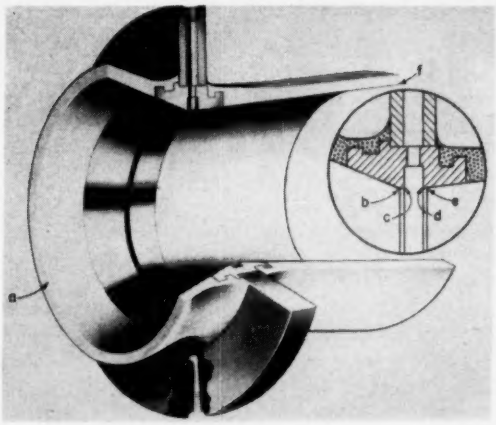


FIG. 2. **PLASTIC** insert Dall tube.

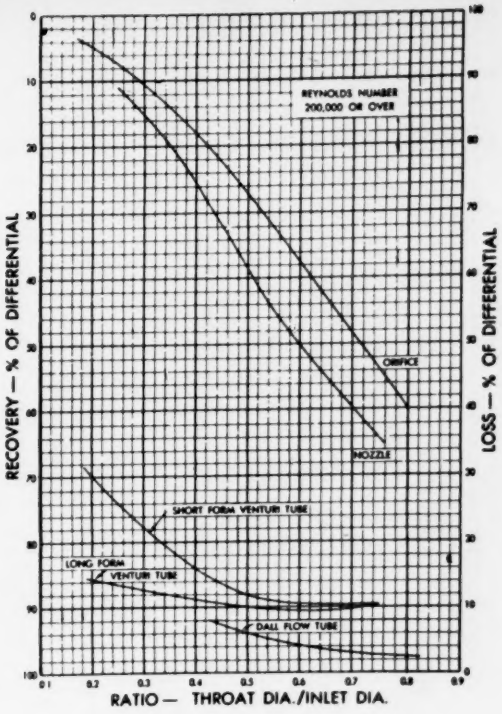


FIG. 3. **RECOVERY** characteristics of various differential producers.

Differential Recovery

Fig. 3 compares pressure loss through several common types of differential producers. At large diameter ratios the Dall flow tube loses as little as 2.5% of the differential. This means that we can have a differential as high as 100" of water with only 2½" of water loss.

This loss comparison is presented as a % of differential because (1) % of differential becomes constant for a given differential producer at high rates of flow, and (2) the primary purpose of a flow meter is to produce a differential which can be read or used to actuate some type of secondary instrument. The one which can produce this differential with the lowest percentage pressure loss is the most efficient.

The pressure-loss measurements were made by reading the pressure difference between a tap one diameter upstream and a tap five diameters downstream from the tube. The pressure loss in the six diameters of pipe without the Dall Flow Tube in place was subtracted from that with the tube in place; the difference was charged against the tube.

Part of this low loss is due to the fact that the differential produced by the Dall flow tube is greater than that produced by the Venturi tube or nozzle with the same diameter ratio. Fig. 4 shows the ratio of the differential produced by the Dall Flow Tube to that produced by a Herschel-type Venturi tube of the

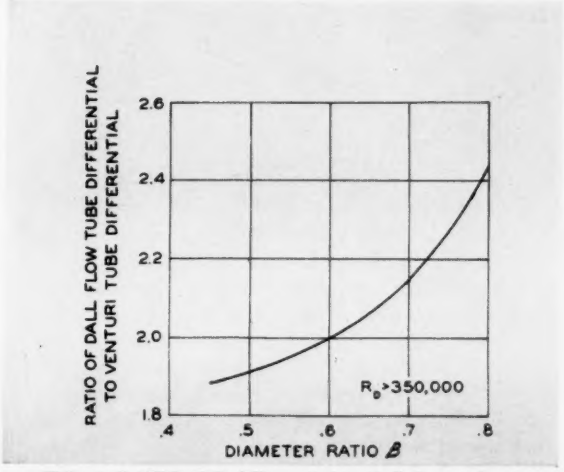


FIG. 4. **RATIO OF** differential in Dall flow tube to that of Venturi tube.

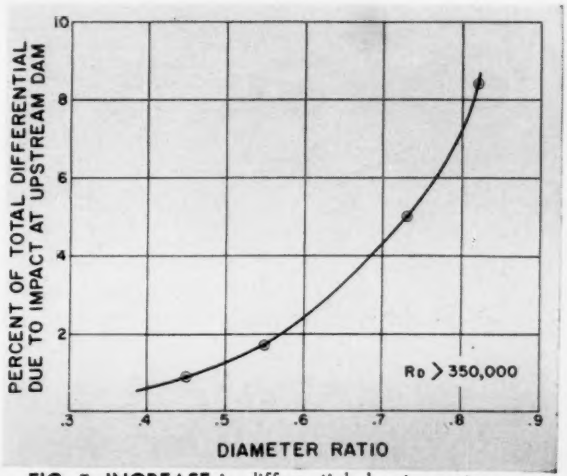


FIG. 5. **INCREASE** in differential due to upstream dam.

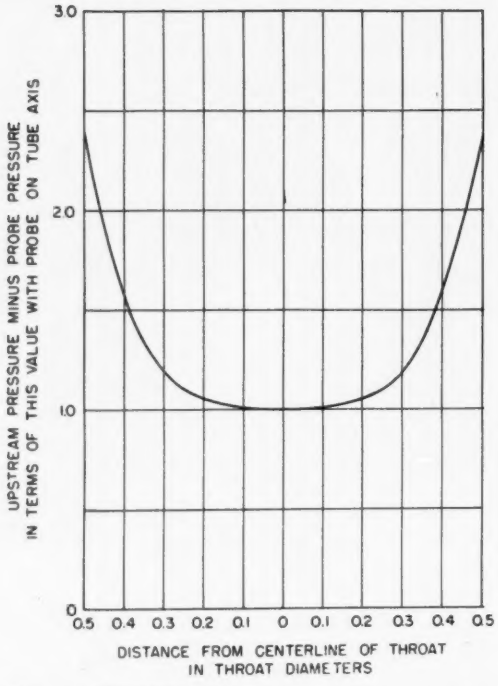

UPSTREAM PRESSURE MINUS PROBE PRESSURE
IN TERMS OF THIS VALUE WITH PROBE ON TUBE AXIS
30
20
10
0
0.5 0.4 0.3 0.2 0.1 0 0.1 0.2 0.3 0.4 0.5
DISTANCE FROM CENTERLINE OF THROAT
IN THROAT DIAMETERS

FIG. 6. DISTRIBUTION of static pressure across Dall flow tube at throat.

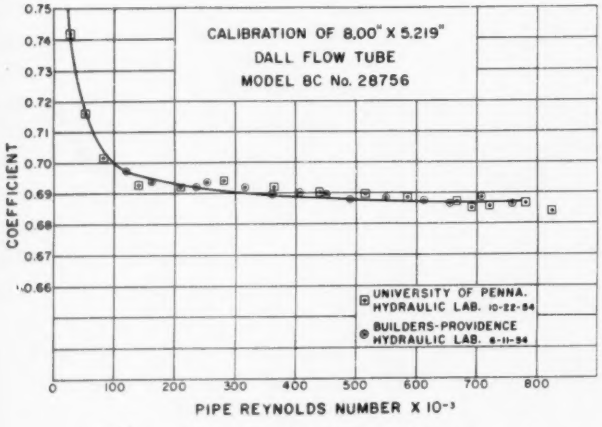


FIG. 7. COMPARISON of calibrations of same (8") tube at Builders-Providence Laboratory and at University of Pennsylvania Hydraulic Laboratory.

same diameter ratio. For a diameter ratio of 0.6, the differential of the Dall tube is twice that of the Venturi tube or nozzle. This ratio increases for larger diameter ratios.

Pressure due to impact at the upstream dam contributes to the large differential, but this increase is not a significant factor (Fig. 5).

A larger portion of the differential is due to the pressure distribution at the throat of the tube. Fig. 6 shows the pressure distribution in the plane of the throat slot. Note: Close to the wall the tube produces almost 2½ times the differential than at the centerline. (This test was made on a 6" Dall flow tube with a 0.354 diameter ratio.) This decrease in static pressure at the wall of the tube is undoubtedly due to the abrupt change in the direction of the flow lines as the fluid passes through this throat section.

Accuracy and Tolerance

Accuracy of differential producers has been the subject of much discussion. It has been the custom for the experts in the field to assign a figure to be used for the accuracy of a given meter, provided it is installed and used in accordance with instructions and that the coefficient value is taken from the proper source.

Professor Jorissen[1] has presented a new concept of accuracy involving "tolerance," which has a more scientific basis and which can be applied to all types of measuring equipment.

Professor Jorissen applies the theory of errors (statistics) to differential producers. The "most probable" value of a series of measurements is the mean or average of that series of measurements. The residuals or deviations are then calculated as the difference between this mean value and each of the individual measurements. Using these residuals, it is possible to calculate a standard deviation for a series of measurements by squaring the deviations, adding them all up, dividing by the number of measurements, and then taking the square root. This is a well-known standard procedure and the formula for calculating this standard deviation is:

$$T = \sqrt{\sum_{n=1}^{n} \delta i^2/(n-1)}$$

If the distribution of errors follows the normal Gaussian distribution, the theory of errors tells us that there is a probability of 68% that the error of any one measurement will not exceed the standard deviation; there is a probability of 95% that the same error does not exceed twice the standard deviation.

Thus, once we have calculated this standard deviation from tests we can be 95% sure that the error of any one measurement will not exceed twice the standard deviation. Dr. Jorissen suggests that we define "tolerance" of a fluid meter as twice the standard deviation. This gives us a quantity which is defined pre-

cisely; there can be no guess work or judgement involved and there are only five chances out one hundred that the error might be greater than this quantity.

This concept could be applied to all types of measuring equipment. To determine the tolerance to apply to a given instrument, it would be necessary to select units at random and test them for standard deviation with a given input value. The tolerance then could be specified as twice the standard deviation.

Tolerance Calculations

We have applied this type of calculation to determine the tolerance of Dall flow tubes. Most of our tests were made in the hydraulics laboratory of Builders-Providence, Inc. The accuracy of this laboratory has been checked against calibration of the same (8″) tubes in the laboratory of the University of Pennsylvania (Fig. 7). The agreement is excellent.

Fig. 8 compares data for an insert-type tube tested in the Builders-Providence laboratory and in the hydraulic laboratory of Cornell University. Note that the coefficient curve is somewhat similar to an orifice plate —that is, one which rises at low Reynolds numbers, rather than decreasing as the Venturi tubes or flow nozzles.

The standard deviation has been calculated for thirty-two Dall flow tubes ranging in size from 6″ to 24″ in diameter and ranging from 0.40 to 0.81 in diameter ratio (Fig. 9). The values were plotted and the best curve was drawn, and the coefficients for each diameter ratio tested were read from this curve. The deviations or residuals were calculated and then the standard deviation calculated. This standard deviation figure came to 0.481%; twice the standard deviation was thus 0.96%. Hence there is a 95% chance that the Dall flow tube will measure the tube flow within 1%, provided it is properly installed and the coefficient value is taken from the mean curve.

Fig. 10 shows this curve with the test points plotted on it. The largest deviation is about 1%, which is for a tube with about a 0.80 diameter ratio. These test points cluster about certain diameter ratios because they have been manufactured in standard sizes but, of course, it is possible to have them made for any size.

I. O. Miner[2] has shown the results of many tests on the Dall flow tube and the effect of various disturbances upstream from this tube. He also states, "Like all other known flow metering elements, the Dall flow tube fails to be outstanding in all respects. It weaknesses are: (1) more straight pipe is required than for some primary devices which have been used for a few decades; (2) the coefficient becomes variable below a Reynolds number considerably higher than that at which a Venturi tube coefficient starts to vary."

References

1. A. L. Jorissen, "On the Evaluation of the Accuracy of the Coefficient of Discharge in the Basic Flow Measurement Equation," *Transactions of the A.S.M.E.*, Vol. 75, October, 1953.

2. I. O. Miner, "The Dall Flow Tube," Paper 54-A-139, *Transactions of the A.S.M.E.*, Vol. 78, April, 1956.

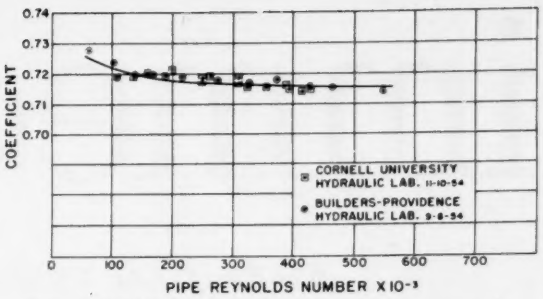


FIG. 8. CALIBRATION OF same (8") tube in Builders-Providence Laboratory and Cornell University Laboratory.

DALL TUBE COEFFICIENT RECORD

SERIAL NO.	SIZE	WHERE CALIB.	β	$\bar{c}$	C_m	$C-C_m$	δ	δ^2
28790	6.00 x 3.909"	B-P	.652	.690	.688	.002	.2906	.0845
29358	6.00 x 2.406"	B-P	.401	.7225	.7200	.0025	.1472	.1204
30633	6.00 x 3.909"	B-P	.652	.6900	.688	.0020	.2906	.0845
31260	6.00 x 3.908"	WPI	.652	.6920	.688	.004	.291	.1
1	8.00 x 5.85"	B-P	.7310	.669	.6628	.0062	.9350	.7740
2	8.00 x 5.15"	B-P	.7310	.662	.6628	.0008	.1207	.0146
5	.00 x 4.197"	B-P	.5495	.710	.7048	.0052	.7320	.5490
28756	8.00 x 5.218"	B-P	.6523	.687	.688	.001	.1454	.0211
	8.00 x 5.217"	B-P	.6523	.686	.688	.002	.2906	.0845
30160	8.00 x 6.337"	B-P	.792	.632	.6265	.0035	.5570	.3100
	8.00 x 4.581"	B-P	.511	.714	.710	.004	.5610	.3170
	8.00 x 5.2165"	B-P	.652	.688	.688	.000	.000	.000
	8.00 x 6.338"	B-P & C.U.	.7195	.626	.626	.000	.000	.000
	8.00 x 4.060"	B-P & C.U.	.5100	.715	.710	.005	.7045	.4960
29193	10.00 x 4.015"	B-P	.4015	.7225	.720	.0025	.3472	.1205
29359	10.00 x 5.242"	B-P	.5242	.7046	.7082	.0034	.4800	.2300
29370	10.00 x 8.02"	B-P	.802	.6270	.622	.005	.8046	.6460
29237	11.933 x 6.327"	B-P	.530	.7055	.7078	.0019	.2686	.0720
29209	11.936 x 9.602"	B-P	.804	.6205	.6205	.000	.000	.000
29149	11.931 x 6.327"	B-P	.530	.709	.7073	.0023	.3250	.1055
29567	11.930 x 4.990"	B-P	.4175	.7150	.7190	.004	.5540	.3090
29585	11.934 x 9.600"	B-P	.804	.6228	.6201	.0025	.4030	.1623
29414	11.935 x 9.5975"	B-P	.803	.6190	.6204	.0014	.2256	.0510
29413	11.935 x 9.598"	B-P	.802	.621	.621	.000	.000	.000
29668	11.936 x 6.329"	B-P	.530	.707	.7072	.0002	.0283	.0008
29656	11.940 x 6.329"	B-P	.530	.705	.7072	.0022	.3110	.0966
29827	12.067 x 9.716"	B-P	.805	.6135	.6193	.0058	.9370	.8750
29826	12.048 x 9.717"	B-P	.806	.6185	.6190	.0005	.0875	.0065
28675	14.002 x 9.249"	B-P	.660	.689	.686	.003	.4375	.1913
31458	20.00 x 10.358"	C.U.	.518	.711	.709	.002	.2820	.0795
33157	21.12 x 15.70"	WPI	.744	.650	.657	.007	1.0500	1.1000
29243	24.025 x 17.544"	C.U.	.731	.641	.6427	.0017	.2565	.0657

$\delta = \frac{C - C_m}{C_m} \times 100$ $\quad \sigma = \sqrt{\frac{\Sigma \delta^2}{(n-1)}} = .4810$ $\quad 2\sigma = 0.962$

FIG. 9. TUBE coefficient data.

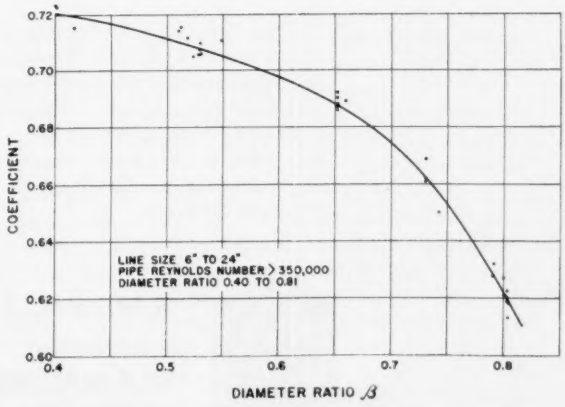
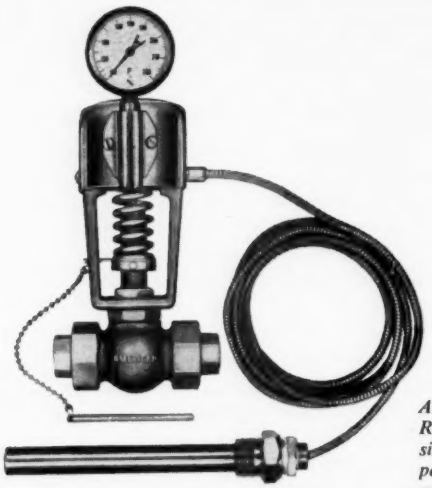


FIG. 10. DALL-FLOW-TUBE coefficient, composite curve.

immediate

AMERICAN TEMPERATURE REGULATORS begin corrective action with less than 1/10 degree change at the bulb



American Temperature Regulators are made in sizes ½" to 4". Temperature ranges as low as minus 15° F. to 50° F.—as high as 240° F. to 350° F.

response

You get fastest possible temperature response from these new regulators because the stem cannot bind and retard valve action.

The valve stem on American Temperature Regulators is sealed off by a friction-free bellows that makes practical a nonleaking packless valve. Also contributing to fast, stable action is the use of an extra-long preflexed adjusting spring. This spring permits a long range of temperature adjustment without disturbing valve sensitivity at normal levels.

There are other high-quality features in American Temperature Regulators: maximum use of stainless steel; standardized parts; the fewest possible components; and unitized assembly. In addition, compactness simplifies installation in "tight" locations.

Accurate temperature regulation and attention-free operation mean long-term economy. Your industrial supply distributor will gladly help you select the right American Temperature Regulators for your needs. Write for Bulletin 114A.

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

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CIRCLE 78 ON READER-SERVICE CARD

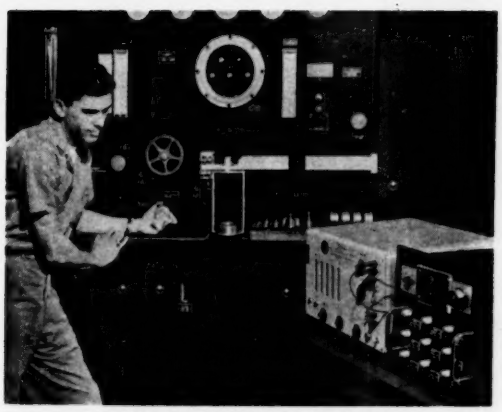


FIG. 1. **FLOWMETER CALIBRATION** apparatus showing scale for measuring collected fuel, electronic timer on panel above scale, and electronic counter which records the number of turns of the rotor inside flowmeter.

NBS FLOW PROGRAM

NATIONAL BUREAU OF STANDARDS has been conducting a liquid-flow-rate standarization program for the Navy Bureau of Aeronautics to provide an accurate basis for the measurement of fuel flow rates in aircraft fuel systems. Directed by M. R. Shafer of the NBS staff, this program has included both a study of current calibration techniques* and the operation of calibration apparatus to serve as a reference for the aviation industry. To provide this reference, the Bureau operates calibration apparatus accurate to 0.2% or better for liquid hydrocarbon flow rates in the range 20 to 100,000 lb/hr.

Among the many different flowmeters available, the glass-tube *variable-area* type is fairly adequate for reference work in the range 20 to 20,000 lb/hr. *Turbine* (propeller-type) meters are reasonably satisfactory for the range 2,000 to 100,000 lb/hr and up. However, precise results can be obtained on these meters only with low-viscosity liquids. In applications involving high-viscosity liquids, such as lubricating and hydraulic oils, *positive-displacement* and *orifice meters* give better results for reference work.

Calibrators Compared

The Bureau constructed a static flowmeter calibrator (Fig. 1) to determine whether significant absolute errors existed in other calibration techniques. This apparatus, accurate to within ±0.15%, collects liquid in a weigh tank during a measured time interval. It was used to evaluate the accuracy of dynamic calibrators, which have the advantage of speed and convenience of operation. The comparative tests between the Bureau's static apparatus and three different types of dynamic calibrators showed that agreement within ±0.15% could be obtained between different methods of flowmeter calibration. The dynamic calibrator now in use is known to be accurate to within ±0.2% for the range 20 to 100,000 lb/hr.

Factors to be Considered

Flowmeter performance is affected by the density, viscosity, and temperature of the liquid, flow disturbances, and vapor pressure with its resultant effect on cavitation and loss of liquid by evaporation. All of these must be considered in precise calibration work. The effects of density usually can be determined by mathematical analysis. Viscosity effects can be established only through calibration tests and these are especially pronounced in the smaller-size meters.

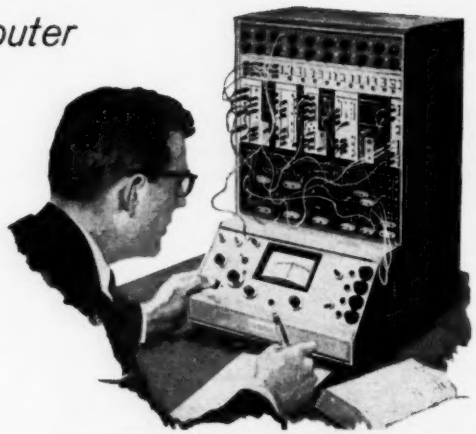
Vapor pressure of the liquid is an important consideration because of the possibility of cavitation or vapor formation within the meter under test and loss by evaporation of the liquid from the weigh tank. Meter cavitation is eliminated by maintaining the fuel within the meter at a sufficiently high pressure. Loss from the weigh tank by evaporation is a definite problem when working with high-vapor-pressure liquids, such as gasoline. The ideal solution appears to be a pressurized weigh system.

The Bureau is continuing its study of flow-rate measuring techniques in an attempt to find flowmeters more suitable for use as transfer references.

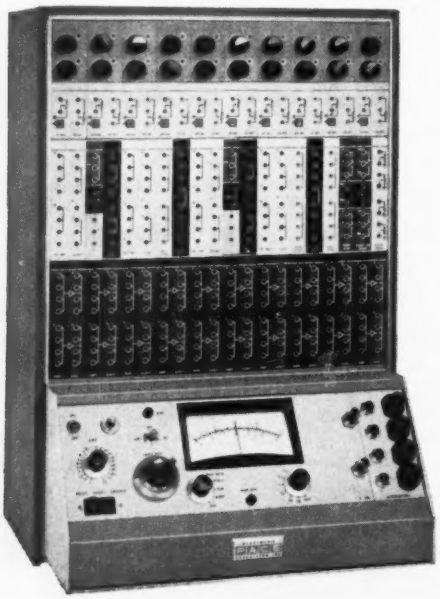
*For further technical information, including a discussion of dynamic calibration techniques, see "Liquid-Flowmeter Calibration Techniques," by M. R. Shafer and F. W. Ruegg, *Trans. ASME*, October, 1958, Paper 57-A-70.

EAI *Transistorized Analog Computer*

A WIDE RANGE OF SOLUTIONS AT DESIGN ENGINEERS' FINGERTIPS...



PACE® TR-10, the first all transistorized desktop analog computer, puts proven high-speed computation right where it's needed – on the desks of busy engineers. With this easy-to-use simulator, you can quickly solve many problems without waiting for scheduled access to large-computing systems. Though compact in size, the TR-10 is a full-fledged analog computer capable of providing solutions to a wide range of design problems. Up to 20 amplifiers, plus linear and non-linear computing components are contained in one compact cabinet with no external racks. The TR-10 permits rapid evaluation of different design approaches. It demonstrates the performance of a conceptual or drawing-board design prior to construction. Thus it saves time and money normally required for multiple test models with cut-and-try engineering.



Here's How The TR-10 Saves Engineering Time

The TR-10 is especially useful in solving problems in such diverse areas as servo-system design, heat flow, chemical reaction analyses, suspension systems studies and many other problems involving dynamic conditions. Fast answers to problems posed by new design ideas immediately determine feasibility of projects. With the TR-10, engineers can explore new ideas as they occur – concentrate valuable time on the most promising area of study.

(Applications notes are available describing typical problem solutions.)

How Do You Use The TR-10?

First—Represent in equation form the physical system to be studied.

Second—Select through a simple computer diagram the computing components required to perform the calculation (programming).

Third—Interconnect these components on the computer (problem patching) and set problem parameters with adjustable controls.

Fourth—Run the problem with results presented graphically on an accessory recorder or oscilloscope.

You now have an electronic analog *model* of the physical system under study. You can manipulate design parameters quickly, running comparative solutions without becoming involved in repeated calculations. With the TR-10 you can rapidly develop truly optimum designs.

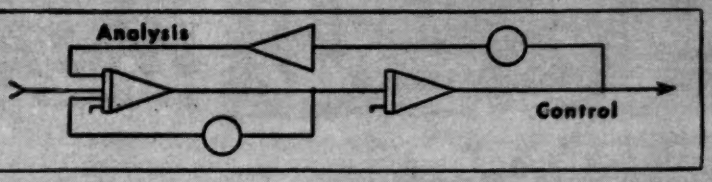
For complete details of TR-10, write for free copy of Bulletin AC 934-DC.

PACE TR-10 Analog Computer, including components for addition, subtraction, multiplication, division, integration and generation of powers, roots, logs, antilogs and arbitrary functions.

EAI ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*

CIRCLE 79 ON READER-SERVICE CARD

The SIMULATION COUNCIL Newsletter



John H. McLeod Jr., EDITOR

Suzette McLeod, SECRETARY

8484 La Jolla Shores Drive,
La Jolla, California

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News

There'll be some changes made!

With the cooperation of Milt Aronson (your Ed's Ed) and, (hopefully) of the Council Secretaries, and (most hopefully) of you readers, your *Newsletter* is not only going to be expanded but will be changed in character somewhat. Among other things we hope to make it more of a NEWSletter and a NewsLATER.

This all comes about in part as the result of opinions expressed at a meeting open to anyone interested in the future of Simulation Councils Inc. which was held in connection with the recent Western Joint Computer Conference in San Francisco.

It's been decided that:

The size of the *Newletter* will be increased and the extra space may be used for publication of complete (i.e. not emasculated by your Ed) technical articles; an extended Letters coverage; reinstatement of a Simulation and Related Events calendar; and coverage of anything else which might be considered of interest. The current (questionable) features of your *Newsletter* will remain unchanged.

Members of Simulation Councils will henceforth be asked to pay annual dues, the amount to be determined by the Board of Directors—probably $3. The reasons are: To establish SCI as a technical society with a bona fide membership as will be required if we are to become a member of AFIPS (American Federation of Information Processing Societies)—which we might; and to make us financially independent.

In return for their dues, members will get: representation (if we're accepted) in AFIPS, which in turn will be the sole representative of the U.S. in IFIPS (International FIPS); the enlarged (and I hope improved) *Newsletter* which will continue to be published in *Instruments and Control Systems*, to which all member will receive a subscription; voting privileges in the Council of their choice; membership in a financially independent organization; and a membership card!

If all this isn't worth $3 (or whatever) to you, "just don't pay the bill"—but *do* come to meetings—and write your Ed anyway.

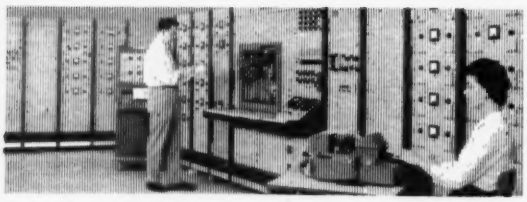
More News?

Saw the omnipresent *Herb Grosch* (didya see he is now doing a column for *Datamation*—"Plus & Minus"; in the March/April issue his invective working fluid is directed at IFIPS). He told Suzy he was off for Australia (via Tahiti!) to be Session Chairman of an ANCCAC meeting at the University of Sydney on 24 May. In four days 186 papers from Australia, New Zealand, (and a few from the U.K. and U.S.) will be presented.

Letters To Your Ed.

"Dear John:

1. This is about the survey requested in the March Simulation Council *Newsletter*. I vote as follows:
   (a) Wine and meat, if at all possible. Not only is this more enjoyable, but, I believe, more informative.
   (b) Abstracts are the next choice. Possibly you can simulate some wine by a liberal insertion of additional remarks and opinions, based on your own knowledge of the people and/or subjects. One italicized paragraph of yours following every sentence of the abstract would be about the right proportion!
   (c) Reprint full text only if (1) you have nothing else available, *and* (2) you don't have the time to abstract them, *and* (3) in *your* opinion they are "significant".
2. Keep up the excellent work. Possibly by sufficient needling, you can train some of the local secretaries to become "wine and meat" suppliers, or, possibly, you can pick your own correspondents (to the great relief of the local secretaries). I will bet that lots of them

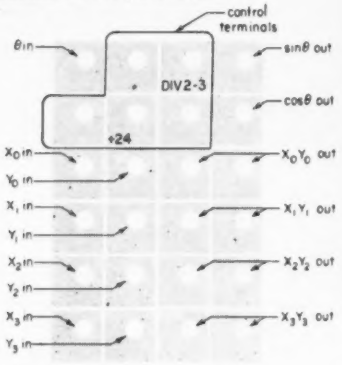


SPEAKING WITH EASE®

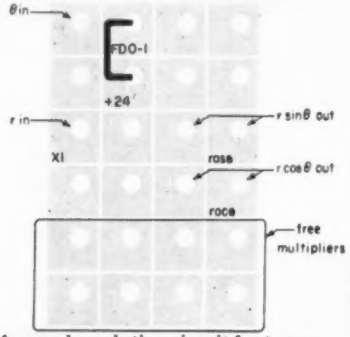
An up-to-the-minute report on computer technology

Electronic Resolution Circuits Formed Automatically

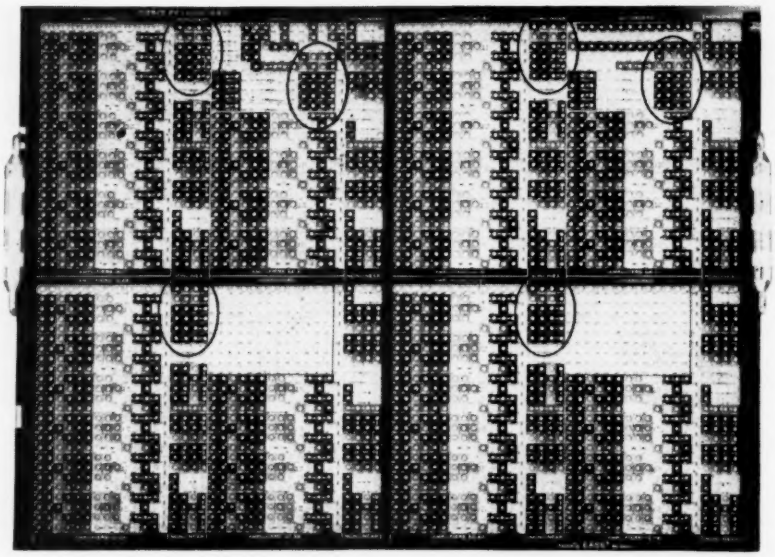
Complete electronic resolution circuits—forward or inverse—can be formed by inserting a single patchboard shunt. The shunt actuates relays that make all necessary connections between sine-cosine function generator, multipliers and amplifiers. Upon removing the shunt, the function generator and multipliers become immediately available for independent use with input and output terminals on the patchboard.



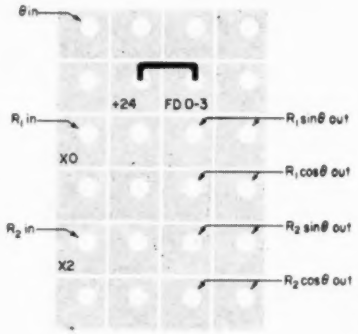
The 24-terminal resolver area contains input and output terminals for one sine-cosine function generator and four multipliers. With the control terminals untouched, all five units are completely independent. Multipliers 2 and 3 may be converted to dividers by connecting a patchboard shunt from the +24v terminal to the "DIV 2-3" control terminal.



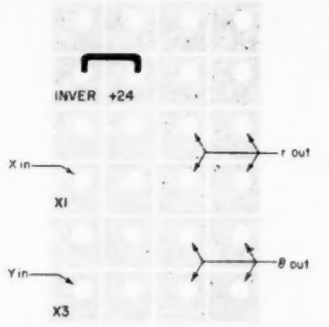
A forward resolution circuit for translating polar to rectangular coordinates is formed by connecting a patchboard shunt from +24v to the "FD 0-1" control terminal. Multipliers 0 and 1 are used in the resolution circuit; multipliers 2 and 3 are free for use elsewhere as multipliers or dividers.



Circled areas on new EASE patchboard are 24-terminal clusters with input and output terminals for forward and inverse resolution circuits. Clusters also contain input and output terminals for four multipliers that may be used independently.



Forward resolution of two parallel vectors is obtained by connecting a patchboard shunt from +24v to the "FD 0-3" control terminal. All four multipliers are employed.



Inverse resolution (translating rectangular to polar coordinates) is accomplished by shunting +24v to the "INVER" control terminal.

Thus we achieve rapid electronic resolution plus the independent use of free multipliers. For further details on EASE resolvers write for bulletins on Model 1154B sine-cosine function generator and Model 1159 multiplier.

C16

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CIRCLE 80 ON READER-SERVICE CARD

are not aware how much fun it is to write up a meeting from a commentator's point of view.*

3. Have you ever seen the enclosed publication?** We have several San Diego subscribers.

Francis V. Wagner, Group Leader
Engineering Computing Group
North American Aviation, Inc.
Los Angeles 45, Calif."

Of course your Editor likes the above letter. Anyone for polemics?

Why no more letters? Can it be that there is nothing else controversial or otherwise worth writing about in our field?

How about these?

Milt Aronson claims digital simulation "ain't simulation!"

Overhead in the Beckman hospitality room at the WJCC:

"An analog computer teaches; a digital computer must be taught. Show me a man that ever learned anything new for a digital computer!"

Pieces

EASTERN S/C MEETING OF 24 NOV. ON PROCESS CONTROLLERS

More on the Eastern SC meetings at Leeds & Northrup. In the February issue of this *Newsletter* we gave you notes on one paper ("Simulation of Industrial Process Controllers" by *Farrenkopf* and *Lapinski*) and the text of another ("Simulation of Cascaded Process Lags" by *Hauser*). But we yelled "too much!" when we tackled the equations of a third paper, "Simulation of Heat and Mass Transfer Equipment" by *Irven H. Rinhard* (American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y.).

After evading the issue for lo these many months we again took a look at the paper, and we still think it is too much (at least for this Newsletter), but we would like to tell you about the paper anyway so that just in case you have a similar problem you can contact the author directly.

Rinhard on Heat Transfer Simulation

Basically the paper covers an investigation of the validity of approximating the heat transfer in two kinds of continuous heat exchangers by simulating the heat exchange in a series of continuously stirred tanks.

The two types of heat exchangers and the approximation used are shown in Figs. 1 and 2, where θ = time, sec; Z = distance from entrance, ft; T = temperature, °F; X = fluid velocity, ft/sec; W = mass flow rate; subscript H denotes hot (tube side) fluid, C is cold (shell side) fluid, W is tube wall.

After an exhaustive* analytical treatment of the single-fluid type, the author states that the analysis of the two transfer functions given points out the basic weakness of the CST (Continuously Stirred Tank) method of approximation. However, the method is useful in simulation since the resonant effect is seldom pronounced in cases of practical interest. But when the dynamics of the process are dominated by a distributed-parameter effect (such as dead time) the CST approximation will give good agreement only at low frequencies. The number of heat-transfer units must be increased considerably to extend the frequency range of the approximation by even a small amount.

Then, having given the countercurrent type of heat exchanger the same treatment, the author states: "Thus, for a countercurrent exchanger it appears that more stages are needed for good approximation of the steady-state gain than were needed for the single fluid exchanger."

Possibly of greatest interest to our readers (or, of greatest interest to our possible readers) is the state-

*Secy's and prospective cores—ah, that is, correspondents—please note.

**DATA-LINK, published 10 times a year by the Los Angeles chapter of the Association for Computing Machinery. Subscription price is $3.00 a year to non-members. The issue Frank sent us was 10 mimeo pages of general and local news of digital computers and people.

*To your Ed., the present participle here would have been a better choice.

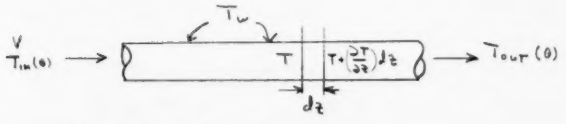


Fig. 1A. Single-Fluid exchanger.

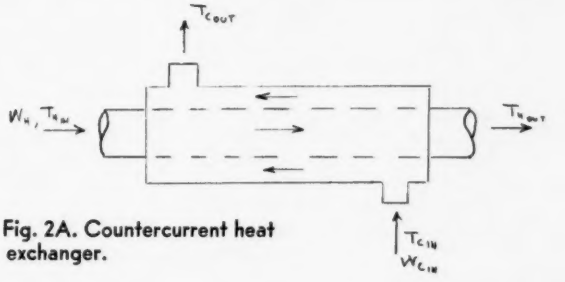


Fig. 2A. Countercurrent heat exchanger.

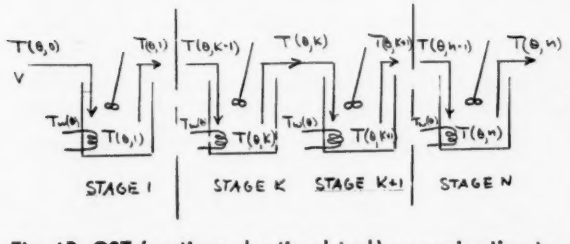


Fig. 1B. CST (continuously stirred tank) approximation to single-fluid exchanger.

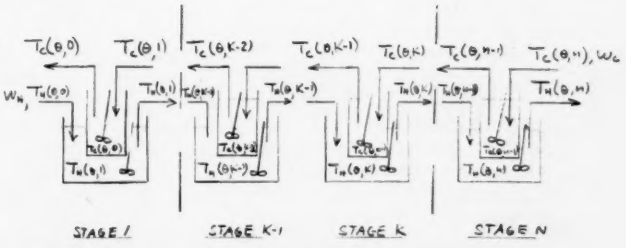
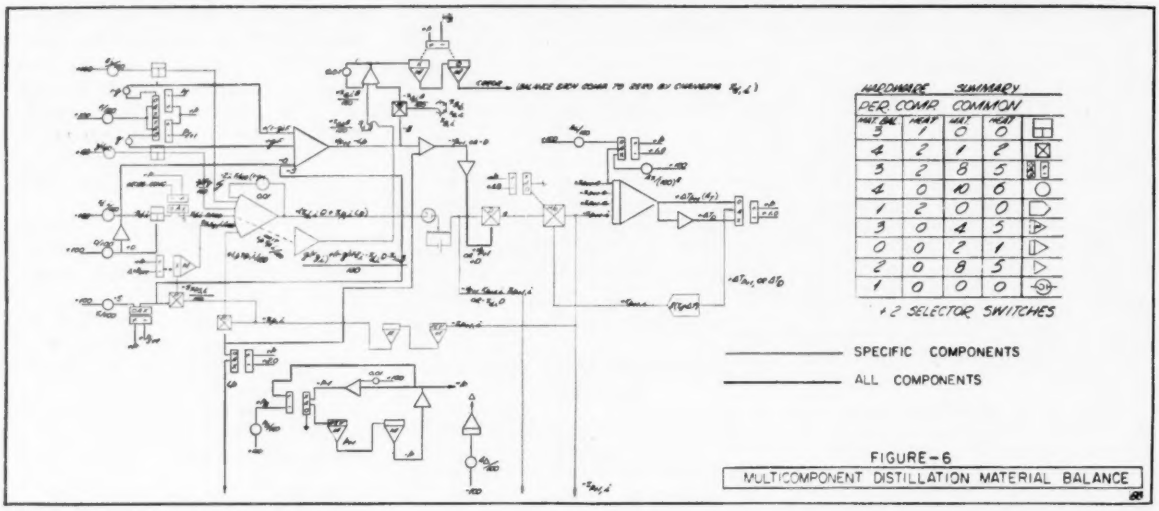


Fig. 2B. CST approximation to countercurrent exchanger.

HOW TO SOLVE MULTI-COMPONENT DISTILLATION PROBLEMS IN 60 SECONDS

• AUTOMATICALLY • ACCURACY TO ±0.05% • FOR ANY SET OF SPECIFICATIONS



Multi-component Distillation Material Balance,
From 13-page design report available on request.

DYSTAC* *completely obsoletes all* other methods for plate-to-plate calculations.

With DYSTAC computers you can now solve design and production problems, control limits, and optimize cost and materials! DYSTAC is truly an advancement in the state-of-the-art. Never before has there been an analog computer which combines the best features of both analog and digital machines.

Here's a partial list of just some of the applications of DYSTAC:

- Heat exchanger design
- Oil reservoir studies
- Transient process problems
- Distillation column design
- Multi-dimensional partials (steady state or transient)
- Regeneration and conversion design
- Fluid flow problems
- Pipelines and piping networks

Not only can DYSTAC solve problems which were previously unsolvable, but DYSTAC is also one of the easiest analog computers to program. Offers the greatest add-on capacity. Assures minimum down time. *Guarantees* its specifications as being minimum standard under *actual operating conditions.*

For the complete 13-page design digest of the multi-component distillation problem-solution, request CSI form #80-1-5-001.

***DYnamic memory STorage Analog Computer**

COMPUTER SYSTEMS, INC., Culver Road, Monmouth Junction, N. J. • DAvis 9-2351

A Schlumberger Subsidiary • formerly Mid-Century Instrumatic Corp.

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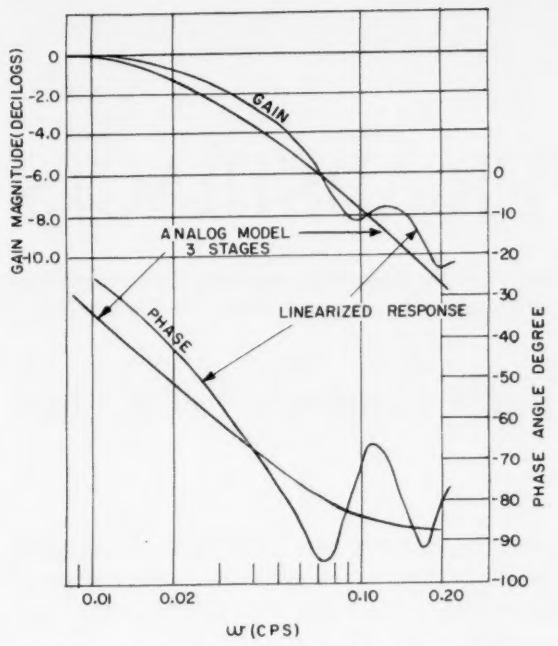


Fig. 3. Response of 3-stage CST approximation.

ment that as a final example of the CST approximation the results of the analog-computer simulation of the countercurrent heat-exchanger mentioned earlier are presented. The response function of interest is that of the hot-fluid outlet temperature to variations in the hot-fluid flow rate. This response function, as computed from a linearized version of the normalized partial differential equations is essentially first order with resonance imposed upon it by the parametric forcing. A three-stage continuously-stirred tank analog was used, based on the lumped-parameter equations. The resulting set of nine ordinary differential equations was the largest that could be handled on the 20-amplifier computer available for the simulation. Servo multipliers were available, so the equations were not linearized with respect to flow rate. Also, it was possible to include the variation of Heat-transfer coefficient with flow rate. The steady-state values of the heat transfer were not adjusted to match the steady-state gain of the simulation to the true steady-state gain.

A frequency response of the three-stage model was performed and the resulting input and output signals were recorded simultaneously on a strip-chart recorder. The frequency response then was determined from the strip charts.

A plot of the frequency response (response of tube-side outlet temperature to tube-side flow rate) is shown in Fig. 3. The gain curve is normalized to the gain value for $\omega = 0.01$ cps. Also shown is the frequency response computed from the transfer function obtained from the linearized version of the normalized partial differential equations, done on the IBM 704 EDPM at the MIT Computation Center. Slightly different values of some of the parameters were used in the two computations. Most of the differences are minor. However, the values of the tube capacitance used in the two cases differ significantly. As it happens, this particular response function is quite insensitive to this parameter; neglecting it entirely changes the results very little. Therefore, both frequency response curves represent the same heat-transfer situation.

The CST approximation again gives results for the lumped-parameter part of the response but fails to show any resonance. A five-stage simulation with no wall capacitance was also tried, with essentially the same outcome. No resonance was observed.

The results of the study of the CST approximation indicate that a fairly good representation of the grosser, lumped-parameter characteristics of heat and mass transfer equipment can be obtained with a relatively small number of stages. This type of simulation would be adequate for simulation of chemical processes involving several pieces of equipment for the purposes of control system analysis and evaluation of plant operability. On the other hand this method is not adequate for a dynamic simulation in which the response of the model is to be compared directly with experimentally-determined dynamic responses. This is especially true if the experimental responses are step responses. Also, if the process dynamics are dominated primarily by distributed-parameter effects (such as dead time) the CST approximation would be considerably in error at higher frequencies.

Smith on Process Optimization

The last talk of the Leeds & Northrup morning session was "Analog Computer Simulation of a Process Optimization Technique" by *G. R. Smith* of the host organization. In the introduction to his paper the author states:

"We have divided on-line optimization, problems into three classes based on the relationship of the time between upsets to the time required to stabilize after a change in a manipulated variable. If we let T_D be the average time interval between disturbances and T_R be the time for the process to come to rest after a disturbance, then we can establish the following classes:

Class I	$T_D >> T_R$
Class II	$T_D \cong T_R$
Class III	$T_D << T_R$

"**Class I:** In this situation we can usually neglect the effects of the transient condition following each disturbance, and the problem becomes one of static optimization.

"**Class II:** In this situation, the process is likely to come to rest after each disturbance, but the time the process is in the transient condition is long with respect to the time in the steady state, and the transient effects no longer can be neglected. This class can be referred to as *quasi-dynamic.*

"**Class III:** In this situation the process is not likely to be at rest at any time. This can be referred to as *fully dynamic.*

"Each of the three preceding classes can be handled differently, but in the methods we have so far considered for all three classes, the value of the static optimum enters into the determination of the true optimum. This has led us to investigate various methods of determining the static or steady-state optimum.

"One approach to determining the static optimum is by means of a systematic search either on the process involved, or on a model of that process. Examples of this technique

LGP-30 COMPUTER ABSTRACTS

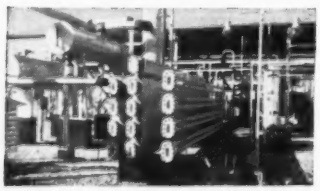
(Application Report #10, from which the following is abstracted, is free upon request from Royal McBee Corporation, Data Processing Division, Port Chester, N. Y.)

Subject: Design / User: Brown Fintube Company, Elyria, Ohio

THE PROBLEM: rush quotation for heat exchanger to potential customer. Determine best heat exchanger vs. cost combination. Perform necessary computations to obtain values for total surface area; total number of exchangers; area/exchanger; velocity and pressure drop – shell and tube; film coefficient; log mean temperature difference; overall transfer rate; clean rate; overall fouled rate; surface actually required; duty; price.

METHOD: the compact, low-cost Royal Precision LGP-30 Electronic Computer.

INPUT DATA: except for special specifications which are handled by design engineers, non-technical personnel fill in data directly from customer inquiry sheets. This information is then punched on tape.



SOLUTION: the engineer reads the above data into storage in specifically assigned memory locations on the computer's magnetic drum. The set of program instructions–also stored on the drum–then directs the computer where to find the input data and what mathematical operations to perform in the proper sequential order. The program then further directs the computer to store the various answers in specifically assigned memory locations.

Of notable interest is the incorporated test feature which allows any type and arrangement of sections to be tested by the computer. The program not only compares calculated values, but provides a corrective computation and recomputes all conditions until satisfactory values are obtained. The engineer need only type in the exact arrangement desired to have the computer calculate his proposed arrangement – assuring complete versatility and control over the program.

OUTPUT: all numbers required for the final specification sheet, including price, are provided – as well as key intermediate answers to enable the engineer to exercise judgment. The computer automatically controls the typewriter so that all answers are printed out in the desired format.

CONCLUSIONS: with the LGP-30, Brown Fintube has reduced total time on typical heat exchanger designs from one or two hours to approximately 3 minutes. Better design vs. cost combinations have been obtained–with a resulting increase in contract awards and the elimination of under-bidding. According to company officials, "perhaps the most significant contribution of the LGP-30 has been the release of engineering manpower for more basic and profound studies."

Royal Precision Corporation

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. LGP-30 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For your free copy of Application Report #10, as well as full specifications on the compact, mobile LGP-30, write today to **ROYAL McBEE CORPORATION,** data processing division, Port Chester, N.Y.

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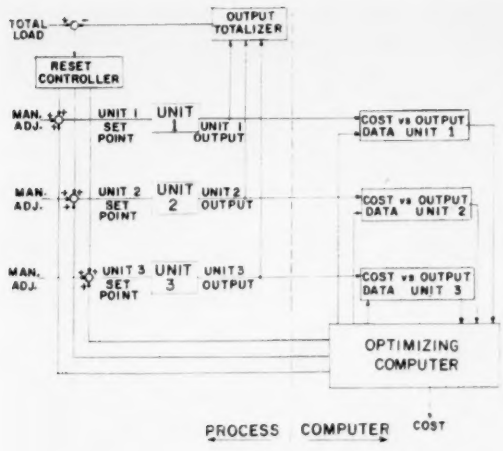


Fig. 4.

include the work of Dr. Y. T. Li*, the Quarie Optimal Controller**, and the Westinghouse OPCON***."

The method of steepest ascent (see former N/L treatments and references) is then considered in general, after which the author states:

"The process selected for our preliminary investigation was a general problem of parallel distribution of a required total. This problem is representative of the problem of economic load distribution among paralleled electric generators with unequal cost-vs-output relationships, or the problem of most efficient distribution of total reactant flow among a group of chemical reactors having different reaction efficiencies due to such factors as catalyst poisoning or heat-exchanger fouling. The optimum desired is to supply the total load at minimum cost.

"A model of the cost *vs* output characteristics of three different units was set up. The characteristics chosen were all of the form

$$C = a_0 + a_1x + a_2x^2 + a_3x^3$$

where C is the cost and x the output. This was done to aid in obtaining an exact closed form solution for any total load to check the accuracy of the optimum as determined by the computer.

"The process was set up to respond to the *sum* of three signals (Fig. 4). One was a manual setting used mainly to enable the optimization to be started from different initial conditions. A second was an integral control signal obtained from the difference between the sum of the outputs and the required value of total output. The third was the signal from the optimizer.

"The output of each process unit, in addition to supplying a signal to the integral controller, supplied a signal to a model of the output *vs* cost relationship. The optimizer also acted on the output-*vs*-cost model and obtained information from the model to determine the correction to apply to the process set point to approach the optimum.

"The process unit, the integral controller and the output-*vs*-cost models were set up on the computer in addition to the optimizer. The optimizer made use of a zero-order hold circuit to obtain and store the value of the cost at this present operating point. Then a test step of fixed size was applied to each cost model in turn, with the resulting new value of cost being obtained and stored on additional zero-order hold circuits.

"At the completion of this cycle the value of the cost at the initial operating point was subtracted from each value of cost and the difference obtained. The three differences were averaged, and the average subtracted from each of the three differences.

"The resulting signal then was applied as an input to an integrator for a fixed time interval, and the output of the integrator applied as a change in the process set point. This process was repeated continuously because it is necessary not only to find a single optimum but to continuously determine the optimum as variations in the required total load occur.

"Some of the error in this approach came about from our method of assuming that a linear approximation would always be valid, and in our method of determining the linear approximation.

"The simulation was performed on our PACE 231-R analog computer as shown in Fig. 5. In addition to the normal computer components, a 22-position stepping switch was used, driven by a comparator relay. A triangular-wave oscillator was used to drive the comparator in order that the speed of the stepping switch could be varied easily.

"Amplifiers 02, 03 and 04 are the *process units;* amplifiers 00 and 01 form the *integral controller;* amplifiers 12, 13 and 14 give the *individual unit costs;* amplifiers 10, 11, 20 and 21 are the *zero-order holds;* and amplifiers 05, 06 and 15 apply the correction signal to the process.

"The *zero-order hold* circuits were obtained by de-energizing the individual amplifier hold relays when a reading was desired, and energizing the hold relays while the reading was to be stored.

"Provision was made for easy adjustment of stepping-switch speed, test-step size, proportion of optimizer output applied to correction integrators, and zero suppression on all readouts.

"The cost-*vs*-output relationship which were used were:

$$C_1 = 5.0 \times 10^{-3}x_1^2 + 25$$
$$C_2 = 4.0 \times 10^{-3}x_2^2 + 0.3x_2 + 30$$
$$C_3 = 2.0 \times 10^{-5}x_3^3 + 3.0 \times 10^{-3}x_3^2 + 20$$

where the C's are costs and the x's are outputs and all are expressed as volts in machine units.

"While the method of steepest ascents determines the best direction in which to search for the optimum, it does not give any indication of how far to move in that direction to find the optimum.

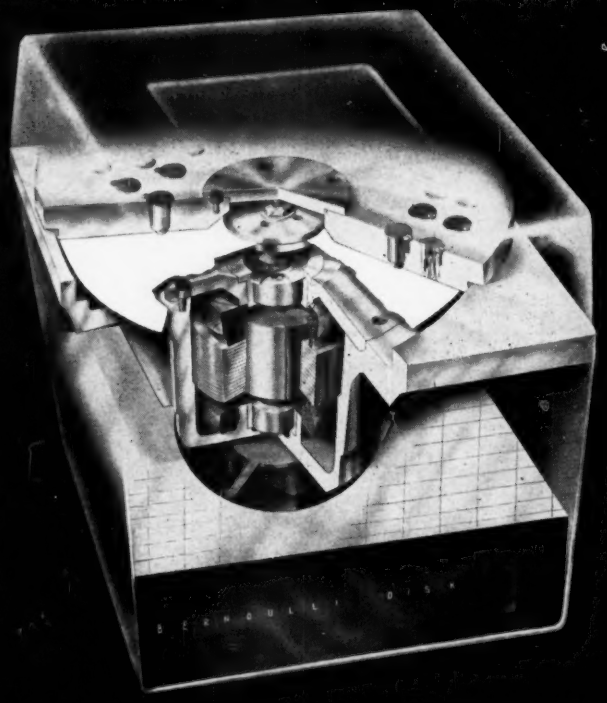
"Selecting the proper-size correction step was much like tuning a simple feedback control loop. Taking too large a correction resulted in a poor approach to the optimum, and repeated oscillations about the optimum much like an under-damped feedback control loop. Too small a correction resulted in taking a long time to come to rest at the optimum. The ideal situation is similar to that

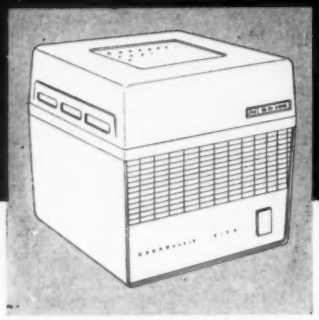
*Li, Y. T., "Principles of Optimalizing Control Systems," *Instruments*, Vol. 25, 1952, p. 72, p. 190 and p. 324.

**White, Byron, "The Quarie Optimal Controller," *Instruments and Automation*, Vol. 29, November 1956, p. 2212.

***Burt, D. A. and Van Nice, R. I., "Optimizing Control System for the Process Industries," *Westinghouse Engineers*, March 1959; Bernard, J. W. and Soderquist, F. J., "Dow Evaluates Optimizing Control," *Control Engineering*, Vol. 6, November 1959, p. 124.

simplest rotating storage device ever developed...





The Bernoulli Magnetic Disk Memory, a proprietary development of The LFE Applied Research Laboratory, is now available in prototype or production quantities.

The first models, designated as the BD-100 Series, are ideally applicable for use in general purpose EDP Systems. In addition, because of each unit's small size and weight, and ability to withstand severe environmental conditions, the BD-100 Series is also applicable to a wide variety of fixed station and mobile digital computers. For a complete description write for Technical Data Digest No. 607I.

SPECIFICATIONS BD-100 SERIES

Storage Capacity (Max) Bits	100,000
Bits Per Track (Max)	3,000
Bit Rate — kc	90-400
Track Layout As Required Typical:	
Total Tracks	40
Data Storage Tracks	32
Spare Tracks	3
Clock and Timing Tracks	3
Register Tracks	2
Number of Registers	4
Register Length — Bits	32
Register Adjustment — Bits	±3
Disk Speed — RPM Induction or Synchronous Motors Available	1800-8000
Power Source — cps	60-400
Magnetic Heads (Compatible with solid state circuits) Typical: (For 200 kc Operation)	
Inductance (Per Leg. — C.T. Coil) — uh	55
Write Current (P/P Manchester) — ma	250
Read Out (Min. P/P Full Coil) — mv	20
Size — Inches (Less Electronics)	9 x 9 x 5
Wide variations from typical specifications can be made to meet customer's requirements.	

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of a critically damped feedback control loop, or possibly one with a small initial overshoot—that is, coming to rest at the desired result in the shortest possible time.

Table 1 shows the accuracy of the results.

"Examination of the results obtained on the analog computer using a 10% test step show a maximum error of 0.6% when compared with the calculated values obtained using the same 10% test step method. This is an indication of the error of the simulation. Comparing the computer results obtained using a 10% test step with the calculated values using the derivatives (the true optimum), a maximum error of 4.5% is found. This is an indication of the error of the 10% test step method. When the test step size was reduced to 2.5% the maximum error between the computer solution and the calculated true optimum was found to be 1.5%."

* * *

Two papers were presented at the afternoon session, but we are informed by *Sid Korn* (at that time Secretary of the Eastern Simulation Council) that these were considered proprietary, so we can't tell you 'bout 'em.

TABLE 1—ANALOG-COMPUTER SIMULATION OF A PROCESS OPTIMIZATION TECHNIQUE

	Calculated Value Using 10% Test Step	10% Test Step	5% Test Step	2.5% Test Step	Calculated Value Using Derivative
x_1	56.9	57.0	56.8	57.0	56.9
x_2	34.9	35.1	34.4	34.1	33.6
x_3	58.2	58.0	58.8	58.9	59.5

WESTERN S/C MEETING OF 15 JAN. ON HUMAN SIMULATION

Captain *S. W. Swacker* welcomed about 90 representatives of some 40 organizations to the Naval Electronics Laboratory in San Diego on 15 January for the first Western Simulation Council meeting of 1960.

The subject was intriguing, currently popular, and important (not necessarily in that order), and the speakers did a good job of presenting "Control Systems with Man in the Loop."

Following the welcome, *George Bekey* (Space Technology Lab. Los Angeles 45, Calif.) introduced *John Stroud*, whom he asked to "talk about man in general terms for 20 minutes." Now if you knew John as we do you'd realize that was a difficult assignment—the 20-minute limit, that is. Whether he made it or not we don't know—we got too interested.

John prepared a talk, had it printed up, and then paid no further attention to it.* What he wrote and what he said were related by subject (and some interesting facts) but there the resemblance ends. We have reason to believe you can get a copy of what he wrote by writing him**, for

*Convention speakers note: Go thou and do likewise!

**John Stroud, Senior Engineer, Vought Electronics, 3110 Goddard Way, San Diego 1, Calif. We recommend it—the talk, not the address.

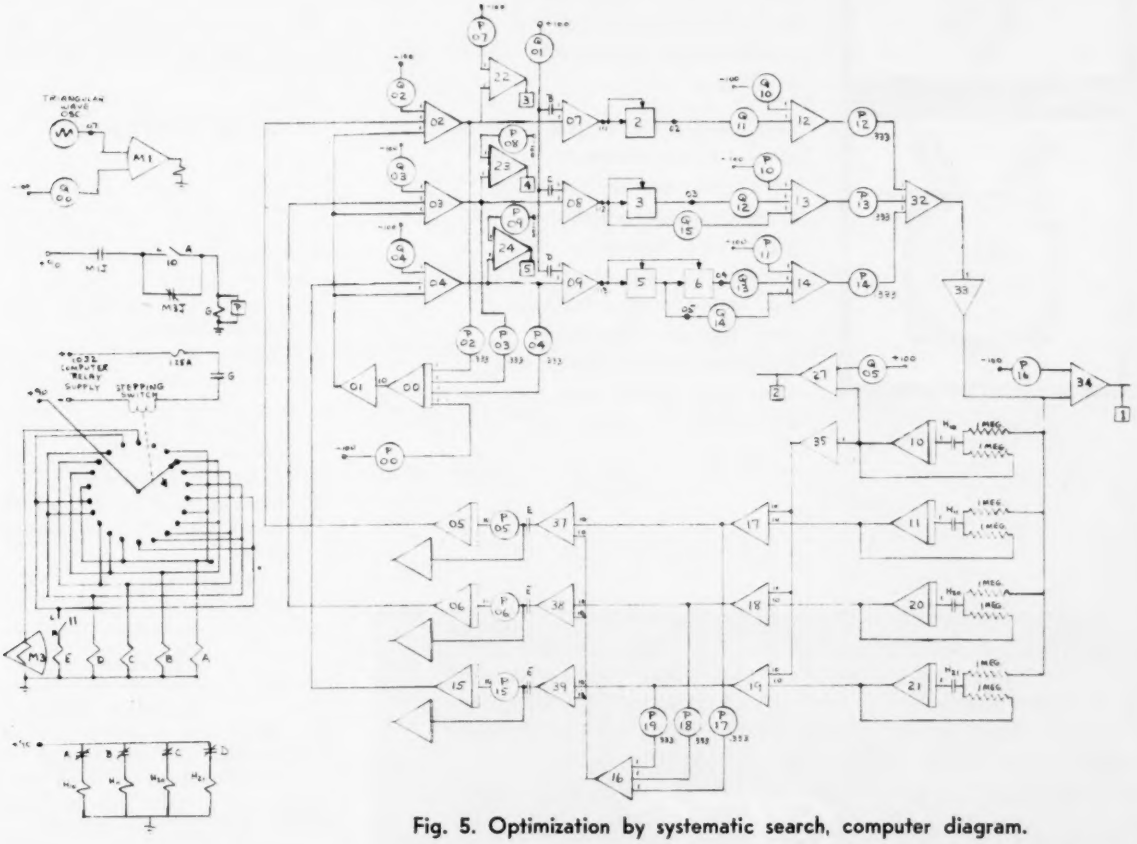
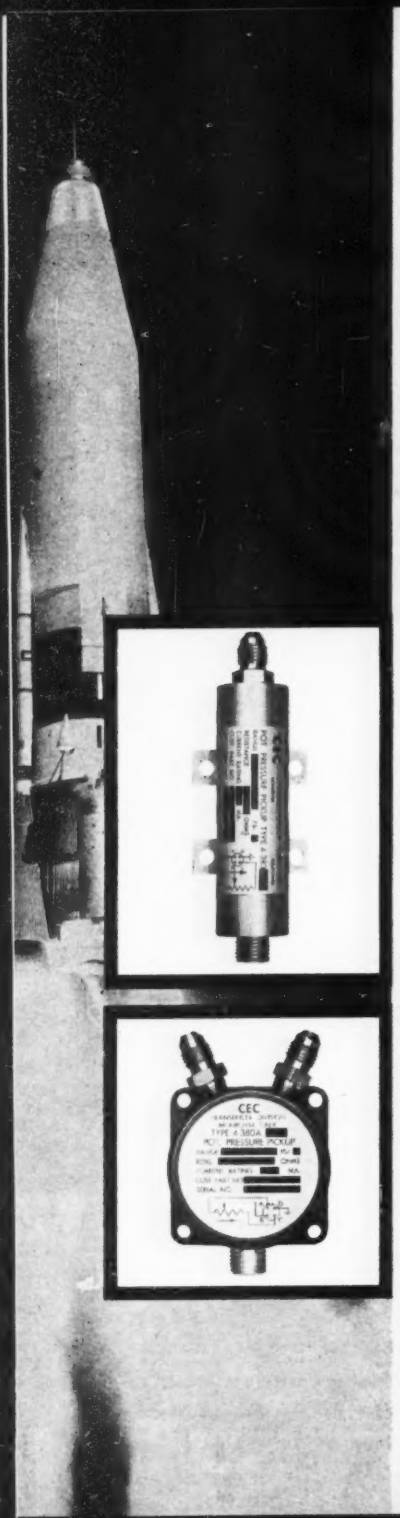


Fig. 5. Optimization by systematic search, computer diagram.



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Here's a rugged pair—one for low pressures and one for high pressures—that can really take shock and vibration. That's why *accurate* in-flight missile pressure measurement is their particular specialty.

THE HIGH-PRESSURE 4-383 comes in gage and absolute models that measure pressure from 600 to 3500 psi. It's a helical Bourdon tube instrument, oil filled and featuring welded construction of 304 stainless steel (no gaskets or O-rings)... fail-safe case that takes 5000 psi ...vibration resistance to 35 g's.

THE LOW-PRESSURE 4-380A uses a force-summing pressure capsule and a pot to measure absolute, gage, or differential pressures from 0 to 100 psi. It features a balanced dual flexure pivot for extreme resistance to the effects of shock and vibration.

You'll want more information on these pot pressure transducers that operate in a range of −65°F to +200°F—with resistance of 5000, 7500, and 10,000 ohms. Write for Bulletins CEC 1604-X30 and 1625-X5, or provide us with your exact requirements for a custom-engineered instrument.

Transducer Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

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"What Kind of a Machine is a Man?", but what he actually said can only be guessed by some of the following excerpts from your Secretary's hurried notes.

"Man is a community of 10^{15} cells, living in a private ocean surrounded by skin . . . You can use this contraption because it is produced in large quantities by unskilled labor. Quality control is bad—nobody knows manufacturer and there are no maintenance manuals. You accept man as a black box because you can't take a screw driver and look inside his head. He has soldered-in connections set up by genetic control mechanism. There is considerable evidence that a human brain maps time like a motion picture—as a series of frames. So a finite number of frames represent a finite amount of time.

"There is evidence that man has some ability to sense within a single frame some motion, but most of the perception of time comes by comparison of several frames.

"Many of the things man perceives are not really there; and many other things that are there he does not perceive.

"If a computer stops thinking like a people and begins thinking like anything else, you're sure it's busted.

"The kinship of computers and man is very close, but computers ain't got no genes.

TO BE CONTINUED

Learn more about "Man the Unsimulatable" in next month's exciting installment! The review of the Western Simulation Council—NEL meeting will be continued with discussions of

1. "Pilot Training for the X-15" by *George Merrick*
2. "Dynamic Response of the Human Operator" by *Duane McRuer*
3. "Computer Simulation of a Human-Controlled Space Ferry" by *J. S. Dobrzanski*
4. "Mathematical Models of the Human Operator" by *George Bekey*

DON'T MISS IT!

Thot

Exhaustive simulation studies at Astronautics and elsewhere have incontrovertibly established that the FAA should require all high speed airplanes and spacecraft to install "HOLD" and "RESET" switches.

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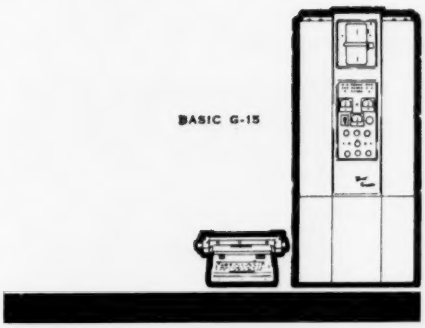

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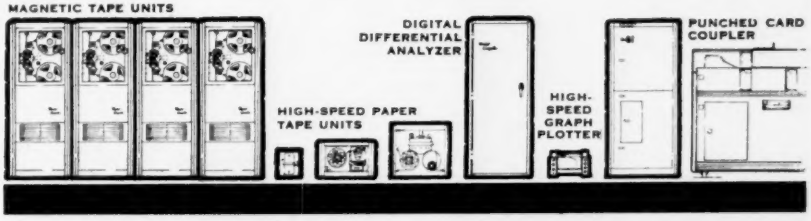

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With the Bendix G-15 you don't have to worry about out-growing your computer for years to come. Start with the basic G-15. It comes with every basic element you need...an alphanumeric typewriter, a paper tape punch, and a high-speed photoelectric tape reader. Then, as your computing needs grow and vary, expand your system by selecting from the complete line of accessories illustrated above. Sale or rental prices are extremely low, and performance compares favorably with systems priced many times higher. Write for details.

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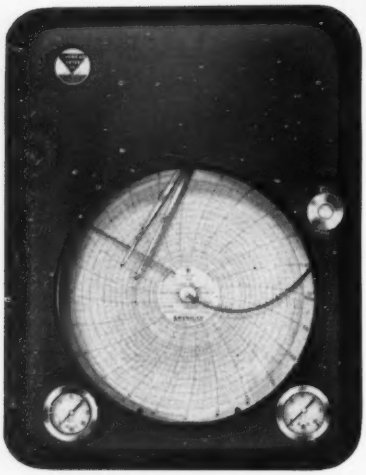

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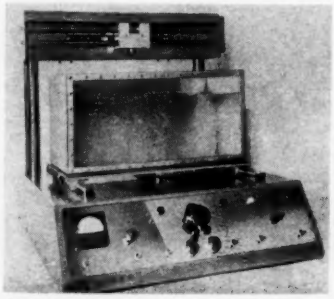
I&CS NEW INSTRUMENTS

ULTRASONIC INSPECTION

New "Mault," a manual and/or automatic ultrasonic laboratory Testing Tank, which measures 26" x 30" x 26" and can be used (1) as a device for establishing production test settings under dynamic inspection conditions, (2) for automatic production testing of small parts, and (3) for establishing optimum ultrasonic test methods and procedure, provides automatic scanning at speeds up to 120 ft/sec.—*Elion Ultrasonics, Inc.*, 430 *Buckley St., Bristol, Penna.*



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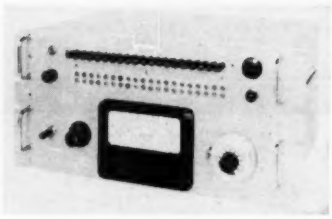
TEMP MEASUREMENT SYSTEM



New, ground-based, modular Temperature-Measurement Systems, TME Series G2, consists of a 20-channel signal conditioner (TME-20HC), a calibration unit (TCE-20HC), and associated temperature transducers. All solid-state, the system has a total range from −320°F to +1000°F. Voltage amplifiers are not required.—*Arnoux Corp.*, 11924 *West Washington Blvd., Los Angeles* 66, *Calif.*

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D-C MULTIPLE METER

New portable, extensively transistorized electronic D-c Multiple Meter is battery operated and provides nine voltage ranges with full-scale readings of 100 mv to 1,000 v. Accurate readings can be made down to the 10-mv range. 12 current measurement ranges are from one μamp to 300 mamp. Five resistance measurement ranges vary from 10 ohms to 100,000 ohms.—*Motorola Inc., Communications and Industrial Electronics Div.*, 4501 *West Augusta Blvd., Chicago* 51, *Ill.*

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MOTOR CLUTCH AND BRAKE

New electrically-actuated positive Clutch and Brake starts the output shaft of the 40 and 80-in-oz motors in 10 msec or less and stops a 1-rpm shaft within 1/10°. Instantaneous positive clutch action is achieved by use of two dished spur gears.—*Hurst Mfg. Corp., Box* 326, *Princeton, Ind.*

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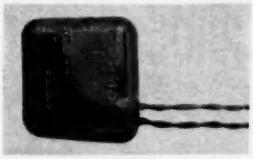
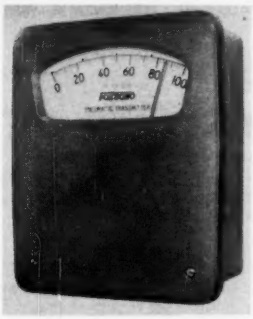
TEMPERATURE TRANSDUCERS



New Series 4100 Temperature Transducers for measuring or monitoring moderate surface temperatures on electronic components, instruments, etc., have been standardized to have 100 ohms resistance change over their range and 500 ohms resistance at their specified low temperature. Composed of a fine platinum or platinum alloy wire as the sensing element, they are encapsulated within a die-formed stainless-steel encasement, and equipped with insulated Constantan wire leads which sustain a pull of 10 lb. Outputs of 5 v can be obtained without the use of electronic amplifiers by using an excitation current of 10 mamp. However, where the ultimate in accuracy and long service repeatability is desired, it is better to restrict the excitation current to 2 mamp, obtaining outputs of one v.—*Convair Instruments, Convair Div. of General Dynamics Corp.*, 3595 *Frontier St., San Diego* 10, *Calif.*

CIRCLE 193 ON READER-SERVICE CARD

INDICATING TRANSMITTER



New line of pneumatic Indicating Transmitters, Model 45 Series, for pressure, flow, temperature, liquid level, differential pressures, and dew point, features measuring elements specifically designed for each major process variable, i.e.: (1) pressure from 0-10″ WC to 0-80,000 psig; (2) temperature from −450°F to +1000°F (−290°C to +5000°C; (3) flow (differential pressure) from 0-1 to 0-400″ WC; (4) liquid level for open vessels 0-10″ WC min; closed vessels 0-20″ WC min; (5) dew point from −50°F to +165°F. Features include high ambient temperature stability, with less than ½% error for ambient temperature changes as great as 50°F, regardless of the variable measured; overall calibrated accuracy, including measurement and output signal, guaranteed to be within ±½%.—*Foxboro Co., Foxboro, Mass.*

CIRCLE 194 ON READER-SERVICE CARD

Sensitive · Compact · Practical

DUBROVIN VACUUM GAUGES

Far More Sensitive Than Mercury Manometer

No. 1451 C. Table Mounting

Made expressly by WELCH For Moderately Reduced Pressures

Range: 0.2 mm To 20 mm of Hg

•

Two Sensitivities Available

•

Pyrex-Brand or Soft-Glass Construction

EASY TO INSTALL - CONVENIENT TO USE

No. 1451 H. Wall Mounting

The Welch-Dubrovin Gauges are made in two basic types. One 9 times and the other 6 times as sensitive as a mercury manometer. Because of this "magnifying factor," the gauge is as sensitive as a manometer whieh uses a liquid of low density, but has the advantage of using mercury which dissolves very few organic or inorganic vapors and which requires no conversion factor. Unlike mechanical or optical magnifying devices, any small errors due to capillarity, adhesion, etc., are not magnified. The smallest division on the 9-to-1 type is 0.2 mm and on the 6-to-1 type is 0.5 mm of Hg. Fractions of these values may be estimated. Both types are available with Pyrex-brand or soft glass in either table or wall mounting.

PRICED AT $47.50 AND $55.00

WRITE FOR COMPLETE LITERATURE.

IF YOU DO NOT HAVE OUR VACUUM PUMP CATALOG WRITE FOR IT.

W. M. WELCH SCIENTIFIC COMPANY

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Manufacturers of Scientific Instruments and Laboratory Apparatus

CIRCLE 87 ON READER-SERVICE CARD

More Accurate Level Reading of LOW TEMPERATURE LIQUIDS . . .

JERGUSON

Large Chamber NON-FROSTING* GAGES

YOU get the highest possible accuracy of reading on low temperature, low boiling point liquids with the patented Jerguson Non-Frosting Gage in the New Large Chamber model . . . because it insures less turbulence at the meniscus, and clear vision at the vision slot.

This new Jerguson model has 6 times larger area at the meniscus than the standard gage, so that there is a marked reduction in turbulence with light gaseous fluids that tend to boil or surge. Moreover, the problem of frosting encountered with these liquids has been eliminated by a patented frost preventing unit extending from the gage glass. This special transparent unit projects beyond the cover bolts and prevents frost from building up over the vision slot.

Here's a dual feature gage that assures greatly increased accuracy of reading for the process industries. If you have a problem with light gaseous fluids, or with gage frosting, it will pay you to investigate the new Jerguson Large Chamber Non-Frosting Gage . . . reflex or transparent.

Jerguson Large Chamber Gage, Transparent Type, with the patented Non-Frosting Gage Glass Extension. Write for literature on this gage, and on other non-frosting Jerguson models.

**Patented*

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Gages and Valves for the Observation of Liquids and Levels

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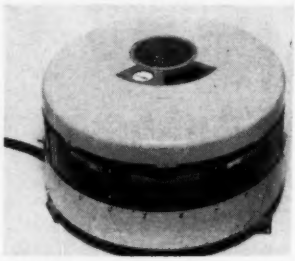
Pétrole Service, Paris, France

CIRCLE 88 ON READER-SERVICE CARD

MEMO DISC



New low-cost Memo Disc storage unit features servo-pneumatic "read" and "write" heads capable of following surface irregularities that would make a fixed head storage drum unusable. Air escaping through an orifice in the face of the head positions the head at 300 μin from the storage surface. Closing spacing on the servo-pneumatic head system increases signal levels and packing density.—*Aeronutronic, a Div. of Ford Motor Co., Ford Rd., Newport Beach, Calif*

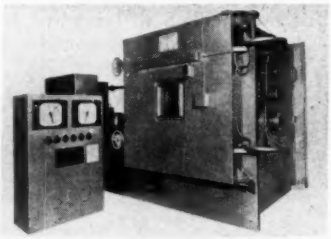
CIRCLE 195 ON READER-SERVICE CARD

CARRIER AMPLIFIER

New Model 688 Carrier Amplifier provides a-c excitation to transducers, such as linear or rotary variable differential transformers and strain-gage bridges, which require an excitation signal of 6.5 v rms at a frequency of 5 kc. The rack-mounted panel unit is completely self-contained including a local oscillator, phase shifter, amplifier, demodulator, filter, meter, and a regulated-voltage supply.—*American Measurement & Control Inc., 240 Calvary St., Waltham 54, Mass.*

CIRCLE 196 ON READER-SERVICE CARD

ENVIRONMENTAL TEST CHAMBER



New Environmental Test Chamber covers temperatures from −100°F to +1000°F reproducing true, high-altitude conditions. Free test space is 4′ x 4′ x 4′. Mechanical refrigeration is capable of dissipating a heat load at the rate of 7500 w @ −70°F.—*American Research Corp., Farmington, Conn.*

CIRCLE 197 ON READER-SERVICE CARD

Both a

PROGRAMMER

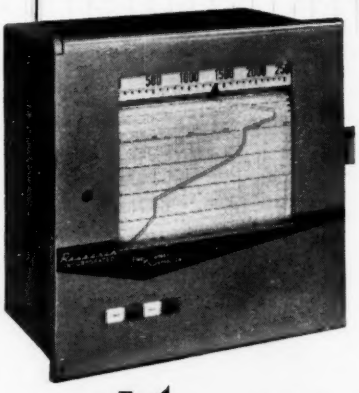
guided by a pencil-drawn curve

NO CAMS

and a

RECORDING CONTROLLER

which superimposes a record of actual process performance and applies corrective control when performance deviates from the plotted program



PREKORDER

TRADE-MARK

brings new flexibility to the automation of industrial process with closed-loop control.

1. **Pencil Programming** — No cams to cut.
2. **Superimposed Recording** — PreKorder's permanent record of process performance on a program chart overlay permits continuous visual comparison of record and chart.
3. **Programmed Limits**—To trigger alarm or shut-down circuits in case of process malfunction, just pencil allowable operating limits on the recording chart.
4. **Programmed Gain**—Varying the space between pencilled program lines varies the proportional control band or system gain.

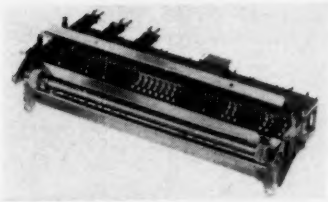
Typical PreKorder applications are in programming temperature, pressure, power, load, flow, position, and other process variables. Both round and strip-chart models are available.

RI RESEARCH INCORPORATED

Write Dept. IC, Box 6164, Minneapolis 24, Minn.

CIRCLE 89 ON READER-SERVICE CARD

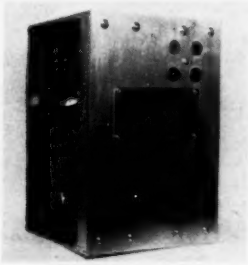
STUNT BOX



New component assembly, called "Stunt Box," gives Model 28 record communication equipment great versatility by (1) initiating mechanically internal functions within the typing unit of the page printer set, (2) electrically controlling functions within the page printer set, and (3) electrically controlling external equipment. Containing forty-two code slots, six are assigned to standard non-typing printer functions while the others are free for a number of additional functions such as vertical tabulation, signal-bell contact, busy-light contact, etc.—*Teletype Corp., 4100 Fullerton Ave., Chicago 39, Ill.*

CIRCLE 198 ON READER-SERVICE CARD

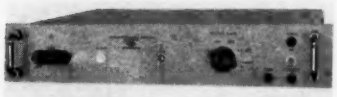
THERMAL SYNTHESIS RELAY



New Relay combines heating effects of positive and negative sequence currents, to protect three-phase motors from damage due to any combination of excessive shaft load. Automatic derating feature permits maximum utilization of motor under all conditions.—*Applied Research Associates of Texas, Inc., 6541 N. Lamar, Austin, Tex.*

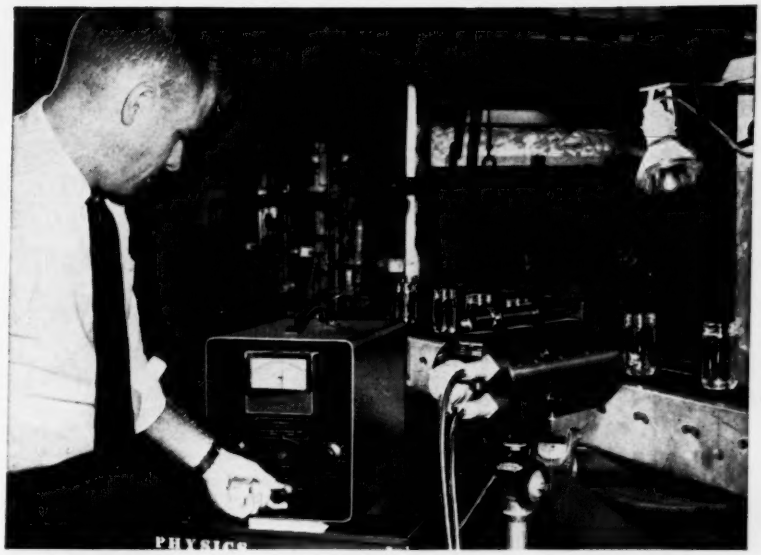
CIRCLE 199 ON READER-SERVICE CARD

VOLTAGE-TO-FREQUENCY CONVERTERS



Two new Voltage-to-Frequency Converters allow d-c and analog voltages to be measured extremely accurately with a standard electronic counter. Model 2211A produces 10,000 pulses/sec for a full-scale input of 1 v; Model 2211B produces 100,000 pulses/sec full-scale. Accuracy of Model 2211A under typical working conditions is better than 0.03%, and for Model 2211B 0.04%.—*Dymec, 395 Page Mill Rd., Palo Alto, Calif.*

CIRCLE 200 ON READER-SERVICE CARD



THERMODOT Model TD-1 measures temperature of moving glass containers without contact

Measuring Temperature Without Contact

THERMODOT® radiation thermometer, Model TD-1, provides sensitive temperature measurement from 100° F to 8000° F with response time as short as 2 milliseconds.

Operating on the principle that an object emits thermal (infrared) radiation as a function of its temperature, THERMODOT determines object temperatures without physical contact. The broad temperature range, fast response, and high sensitivity of THERMODOT have led to the solution of a number of industrial problems. Current applications of THERMODOT include:

Paper: Measuring paper and dryer temperatures for moisture control.

Plastics: Temperature monitoring of plastic film and sheet in extrusion, coating processes.

Rubber: Nondestructive testing and quality control. Detection of "hot spots" on tires during high speed tests.

Fibers: Temperature gradients, cooling rates for research, quality control.

Metals: Temperature measurement and control during annealing and heat treating; high speed measurement during induction, resistance heating.

Aircraft and Missile: Rapid temperature variations of structures and materials subjected to thermal loading or simulated high speed flight.

For more information on THERMODOT, Model TD-1, write for Bulletin R-101

Complete systems for temperature measurement and control have been designed for many industries. Prompt attention will be given to your special problems by our experienced scientific and engineering staff.

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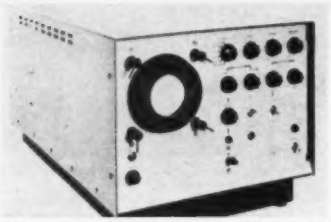
CIRCLE 90 ON READER-SERVICE CARD

FAST OSCILLOSCOPES



New fast Oscilloscopes, Model 707 and 708, in the Milli-Mike line are of the traveling-wave deflection-type, and display both single transient and repetitive phenomena in the milli-microsecond and sub-millimicrosecond regions. The display area can be varied from 1 x 1.5 cm @ 20 kv to approximately 3 times this size @ 3 kv, permitting more information to be contained in the unmagnified display than is normally found in a conventional 5" KRT oscilloscope. Other features include high writing speed, and highest sensibility.—*Edgerton, Germeshausen & Grier, Inc.*, 160 *Brookline Ave., Boston* 15, *Mass.*

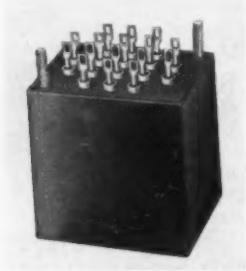
CIRCLE 201 ON READER-SERVICE CARD

PRECISION POWER SUPPLY

New Model 351A rack-mounting Power Supply is adjustable in one-μamp increments and provides regulation to better than 0.01% with an output of 0 to 100 ma at a maximum of 100 v. Long term stability of 0.01% is assured by the use of chopper stabilization against a standard cell reference.—*John Fluke Mfg. Co., Inc., Box* 7161, *Seattle* 33, *Wash.*

CIRCLE 202 ON READER-SERVICE CARD

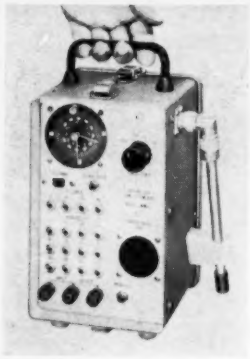
MAGNETIC MODULATOR



New Modulator is essentially a low-power level magnetic amplifier. Input is 115 v @ 400 cps and output is from 0 to 3 v and 0 to 2.5 v with a reversible phase. D-c signal input is 0 to $\pm$100 μamp with a 20% maximum distortion of output. Load of unit is 12,000 ohms.—*Freed Transformer Co., Inc.*, 1718 *Weirfield St., Brooklyn* (*Ridgewood*) 27, *N. Y.*

CIRCLE 203 ON READER-SERVICE CARD

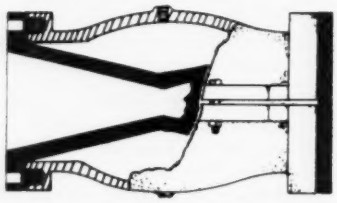
SECONDARY TIME STANDARD



New portable, self-powered Secondary Time Standard, Model WWV-1, is accurate to approximately $\pm$16 sec/year, and can be used for precisely timed, on-off control of recording instruments, telemetering transmitters, etc. Completely transistorized, and weighing only 9 lb complete, it is engineered to receive Station WWV, and other accurate time sources at any of the frequencies or 2.5, 5.0, and 10 Mc.—*Zenith Radio Corp.*, 6001 *West Dickens Ave., Chicago* 39, *Ill.*

CIRCLE 204 ON READER-SERVICE CARD

REDUCED PORT PINCH VALVE



New rubber Pinch Valve with reduced ports gives a more streamlined flow pattern of slurries where abrasion and corrosion problems play an important role. Standard sizes are 1" x 2", 1¼" x 1½", 2" x 3", 3" x 4", 4" x 6", and 6" x 8".—*Red Jacket Co., Inc., Bell Ave., Carnegie, Penna.*

CIRCLE 205 ON READER-SERVICE CARD

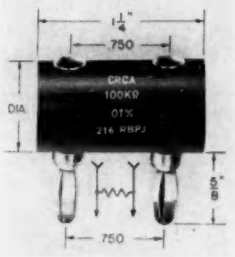
HI-TEMP MERCURY RELAYS

ACTUAL SIZE

New miniaturized family of 30 amp/115 v A-c Mercury Relays is hermetically-sealed and gives various time delays for a-c relays without using thermal delay mechanisms. Enables remote control wiring with low-voltage to the switch for homes; yet it handles strong current loads. Three groups of relays are available: (1) for ordinary temperature requirements, (2) for temperatures up to 500°F, and (3) for ultra-high and ultra-low temperature needs.—*Sorrels-Johnson Corp.*, 363 *Rantoul St., Beverely, Mass.*

CIRCLE 206 ON READER-SERVICE CARD

BANANA PLUG RESISTORS



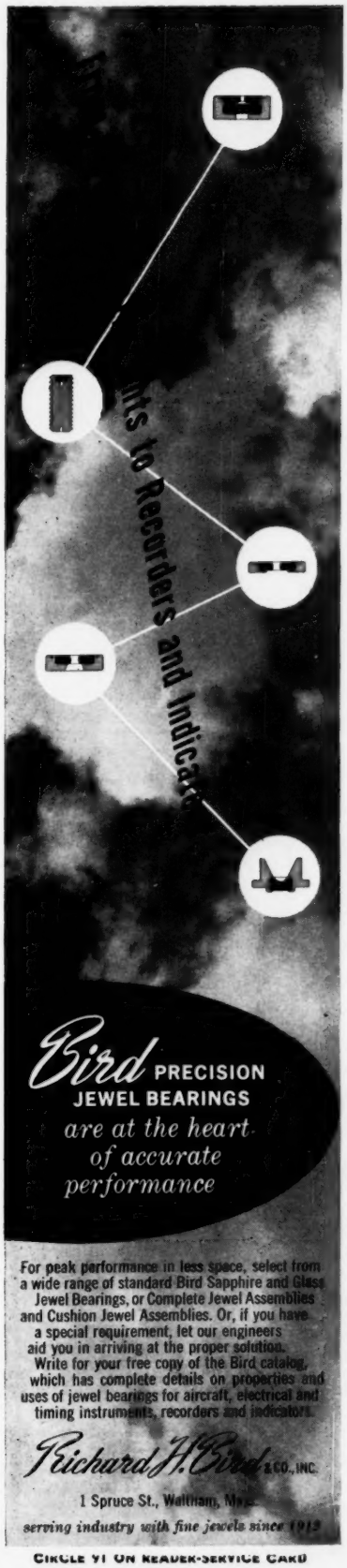
New Banana Plug Resistors, available in 8 standard sizes from ¼ to 2-w power dissipation, have the following general specs: Type: non-inductively wire-wound (also carbon and metal film); tolerance: 1% thru 0.005% abs; stability: thru 0.001%; temperature coefficient: thru 5 ppm/°C abs; impregnation: hermetic seal in epoxy resin; MIL specs: applicable sections of MIL-R93B and MIL-R9444.—*Consolidated Resistance Co. of America, Inc.*, 44 *Prospect St., Yonkers, N. Y.*

CIRCLE 207 ON READER-SERVICE CARD

CAM-OPERATED VALVE

New Roller Operated Two-Way Valve features a hardened and ground poppet-and-seat assembly, lapped together, so that in the closed position there is no internal leakage. Valve body is made from heat-treated aluminum-alloy bar stock. Poppet and seat are case hardened steel. Maximum allowable pressure at "in" port is 1500 psig, at "out" port is 500 psig. Rated flow is 30 gpm. Force required to operate plunger is 45 lb.—*Barworth, Inc.*, 681 *Morris Turnpike, Springfield, N. J.*

CIRCLE 208 ON READER-SERVICE CARD



Bird PRECISION JEWEL BEARINGS *are at the heart of accurate performance*

For peak performance in less space, select from a wide range of standard Bird Sapphire and Glass Jewel Bearings, or Complete Jewel Assemblies and Cushion Jewel Assemblies. Or, if you have a special requirement, let our engineers aid you in arriving at the proper solution. Write for your free copy of the Bird catalog, which has complete details on properties and uses of jewel bearings for aircraft, electrical and timing instruments, recorders and indicators.

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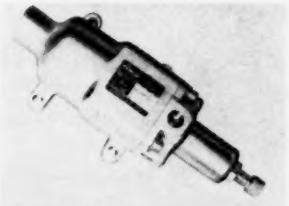
CIRCLE 91 ON READER-SERVICE CARD

HI-PRESS THERMAL WELLS

New Wells which can handle pressures up to 3000 psig @ 600° F, or 2000 psig @ 700° F are available in three styles: coupling head, hex head, and with a moisture-sealed, tamper-proof cover. All are made of Type 316 s.s. with heliarc-welded junctions. —*Fenwal Inc., Pleasant St., Ashland, Mass.*

CIRCLE 209 ON READER-SERVICE CARD

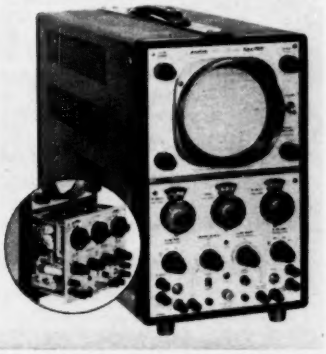
VIBRATION VALVE



New Model 2900 Vibration Valve is employed as a 2- or 3-way, snap acting, non-overlap vibration monitoring valve on pneumatic or hydraulic control systems to 80 psig. The valve can be applied as an accessory to the 1476-line of basic Amot controls, or it can be used by itself to energize auxiliary devices. An internal cylinder is provided to reset the tripping mechanism, with the application of 40 to 80 psi.—*Amot Controls Corp., First St., & Nevin Ave., Box* 1707, *Richmond, Calif.*

CIRCLE 210 ON READER-SERVICE CARD

PRECISION OSCILLOSCOPE



New Type 1100/700 Oscilloscope features an anti-parallax scale, to avoid the usual reading errors from the cathode-ray tube screen. Of special modular design, the main frame is a basic, self-operable cathode-ray tube indicator, and the Type 700 is a dual-channel plug-in, incorporating 1% null-readout potentiometers for measuring amplitude and sweep-time. —*Analab Instrument Corp.,* 30 *Canfield Rd., Cedar Grove, N. J.*

CIRCLE 211 ON READER-SERVICE CARD

Here's a complete ½" In-Line Valve with a 7.5 C_v! Springless (pneumatic or hydraulic), spring-to-open or spring-to-close operation. The operating method can be changed easily in the field without extra parts.

Write or call today for complete details on this extraordinarily compact In-Line Valve for on-off or control applications.

OTHER SIZES AND END CONNECTIONS AVAILABLE

GEORGE W.
DAHL
COMPANY, INC.
86 TUPELO STREET
BRISTOL, RHODE ISLAND
CLifford 3-9500

VALVES AND CONTROLS FOR THE COMMUNICATIONS, PROCESS AIRCRAFT AND MARINE INDUSTRIES

CIRCLE 92 ON READER-SERVICE CARD

NEW FULL-VIEW® ROTAMETER

Interchangeable metering tubes snap in and out . . . in seconds! It's that easy to change range or to service the new Brooks Series 1112 Full-View Rotameters.

A stainless steel leaf spring (entirely isolated from the process fluid) holds the tube perfectly in position, yet allows removal with just a simple up-and-out movement. No tools necessary.

Special O-ring construction and tube adapter assemblies make this time-saving convenience possible. Up to four different size metering tubes may be interchanged in a single case by merely changing adapters.

Like all Full-View Rotameters, the new Series 1112 features Brooks' dowel-pin, side-plate case construction. Thoroughly proven in service, this practical construction gives the meter case rigid strength, protects the glass metering tube from all line strain.

For More Information, Request Design Specification Sheet SS-111-2

BROOKS ROTAMETER COMPANY

660 J STREET, LANSDALE, PA.

B.A. 1037

CIRCLE 93 ON READER-SERVICE CARD

DATA AMPLIFIER

New Type 492 completely-transistorized two-channel Data Amplifier features a gain accuracy of 0.01%. A true differential-input amplifier, several hundred volts may be applied between the input and ground without giving interference. Gains of 100, 250, 500, and 1000 are selectable by a panel switch. A total of 16 channels can be mounted in 8¾" of standard 19" rack space. Linearity is ± 0.01% for 10-v output; response to step input is 99.7% in 0.0025 sec.—*Offner Electronics Inc., 3900 River Rd., Schiller Park, Ill.*

CIRCLE 212 ON READER-SERVICE CARD

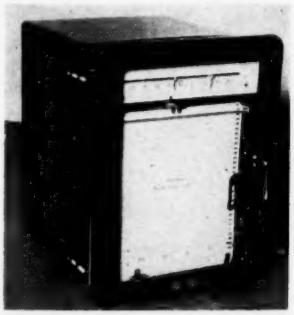
LIFE-TEST OVEN

New elevated-temperature thermostatically-controlled Life-test Oven handles 660 bi-polar components or 330 tri-polar devices. Standard units are rated at 125°C max. Test circuitry is rated at 750 v and 5 amp with resistance less than 0.5 ohm. Power requirements are 1600 w/115 or 230 v and 50 or 60 cps.—*ITT, Components Div., 815 San Antonio Rd., Palo Alto, Calif.*

CIRCLE 213 ON READER-SERVICE CARD

LIMIT-CONTACT RECORDERS

New on-off Contacts which are inductively coupled to the transistorized control circuit allow standard recorders to be equipped with either one or two set points for maximum/minimum control. The two contacts can be adjusted for a minimum separation of ⅜" (about 7% of full scale on standard size recorders). Accuracy of control varies between 0.5% at the center of the scale and 3.0% of the end of the scale.—*Curtiss-Wright Corp., Princeton Div., Electronic Instrument Dept., Princeton, N. J.*



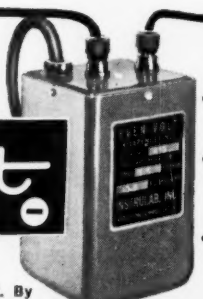
CIRCLE 214 ON READER-SERVICE CARD

INSTRULAB'S NEW

evenvolt

Constant Voltage Unit

REPLACES BATTERIES IN POTENTIOMETERS
- CONTROLLERS
- INDICATORS
- RECORDERS



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Outstanding FEATURES
- Eliminates batteries ...errors due to battery exhaustion
- Reliable construction...from quality components, long, trouble-free service
- A Precise voltage regulator . . . max. ±.04% for ±20% voltage variation
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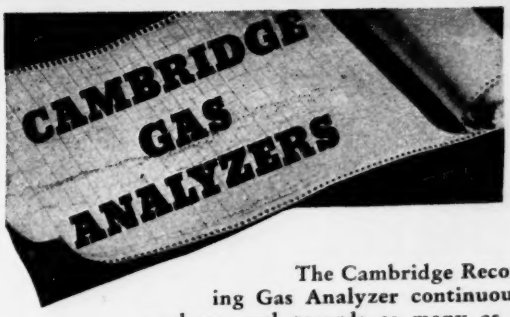

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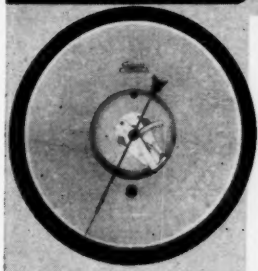

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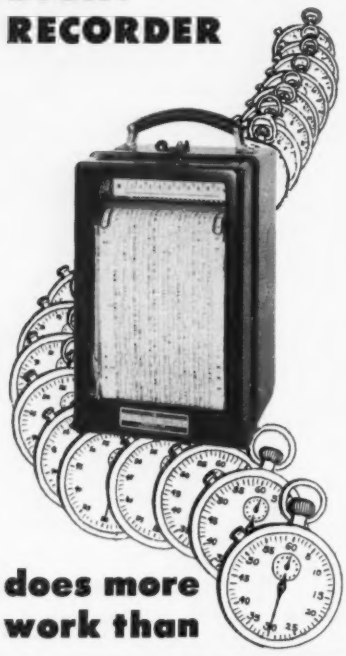

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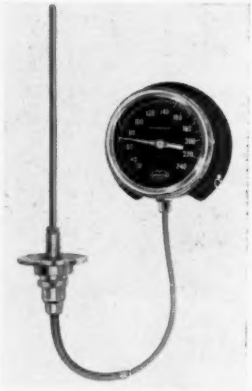
HI-SPEED ALARM SCANNER

New solid-stage Magne-Alarm Scanner for millivolt and higher level signals can handle from 1,000 to 20,000 points/sec. Accepts inputs from thermocouples, strain gages, external voltages, or resistances, and provides a minimum of 130 db common mode rejection at 60 cps. Bulletin gives details.—*San Diego Scientific Corp., 3434 Midway Drive, San Diego 10, Calif.*

CIRCLE 215 ON READER-SERVICE CARD

DIAL THERMOMETERS

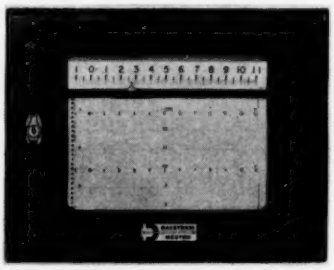


New mercury-actuated Dial Thermometers for duct applications feature a uniformly graduated scale for the entire range, a micrometer adjustable pointer, all stainless-steel system for quick response and long life, plus a 10″ to 12″ sensitive s.-s. bulb with union connection flange. Enclosed in black-enameled aluminum cases with chrome-plated slip ring, they are also available with fully compensated line up to 200 ft. long. Sizes are: 4½″, 6″, and 8″. Std. ranges are: —40/110° F, —20/110° F, 30/150° F, 30/240° F, 100/400° F, 100/800° F.—*Weksler Instruments Corp., Freeport, N. Y.*

CIRCLE 216 ON READER-SERVICE CARD

PEAK PICKING RECORDER

New Peak-picking Recorder, Model 6707, for process gas chromatography, records peak heights only, printing them as successively-numbered points on a slowly moving chart. Because of the slow chart speed and the condensed data recorded, hours of stream analysis can be studied in the recorder window at any given time.—*Weston Instruments Div., Daystrom, Inc., 614 Frelinghuysen Ave., Newark 12, N. J.*



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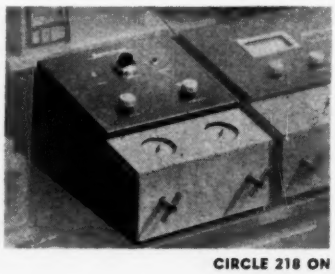
HYDROGEN FLAME DETECTOR



New Hydrogen Flame Detector is an accessory to supplement the standard thermal conductivity detector used in the Beckman GC-2 Gas Chromatograph. Its ultra-high sensitivity of 50 ppb full scale, is especially suited for detecting the presence of minute traces in complex organic compounds.—*Beckman Scientific and Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.*

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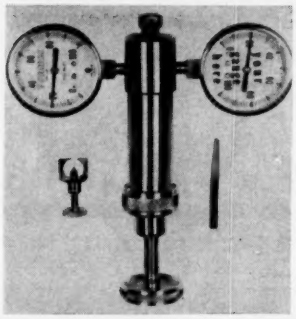
PRESSURE GAGE TESTER



New Pressure Gage Tester comes complete with tools for correcting faulty gage readings. Units are available in chromium-finished brass and stainless steel from 50 to 300 psig.—*Terriss Div., Consolidated Siphon Supply Co., Inc., 22 Wooster St., New York 13, N. Y.*

CIRCLE 219 ON READER-SERVICE CARD

DIGITAL READOUT SYSTEM

New digital temperature and pressure Readout System is operated from resistance temperature bulbs in the 0°-1400°F range and from resistance pressure transducers ranging from 0-10,000 psig. System reads out combinations both of temperature and pressure while other systems must depend upon individual devices to read out these two basic performance indicators. Accuracy is in the magnitude of ½% to 2% absolute (depending upon range and transducers). The system is capable of remote interrogation because information is encoded for telemetering. Temperature and pressure may be monitored from as many as 99 different points. —*Texas Instruments, Inc.*, 3609 *Speedway, Houston 6, Texas.*

CIRCLE 220 ON READER-SERVICE CARD

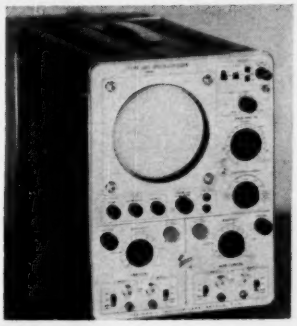
STEPLESS INPUT CONTROLLER

New electro-thermally-actuated Stepless Power Input Controller can be set at any percentage of "time on" from 5% to 100%, and automatically compensates for wide variations in voltage and ambient temperature. Has built-in magnetic arc suppression. Bulletin CN801 gives details.—*Thermo Electric Mfg. Co., 465 Huff St., Dubuque, Iowa.*

CIRCLE 221 ON READER-SERVICE CARD

X-Y OSCILLOSCOPE

New differential-input X-Y Oscilloscope, Type 503, with sensitivity of 1 mv/cm in the dc-to-450 kc range, utilizes a minimum number of tubes (equivalent 17 plus rectifiers), and has identical vertical and horizontal amplifiers. Characteristics include: input stages electronically regulated, calibrated steps to 20 v/cm, adjustable between 14 steps, and to over 50 v/cm uncalibrated, differential input, and constant input impedance (for easy probe use) at all sensitivities.—*Tektronix, Inc., Box 831, Portland 7, Ore.*



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SAMPLER
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MODEL
130-7
For obtaining more accurate gas sampling, this proven Arcco-Anubis instrument is unexcelled. It replaces older, inadequate methods for spot sampling. This sampler will over a period of seven days accumulate at a constant rate a sample of gas to a final pressure at or near 130 psig from a sample source, the minimum pressure of which is not less than 150 psig.
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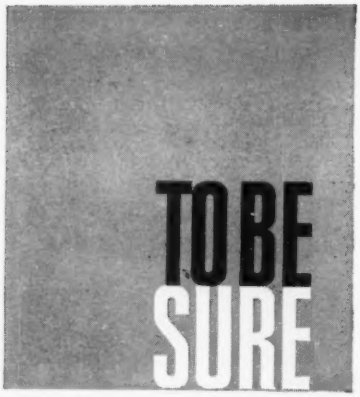

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Features: M24 measures DC voltage, voltage ratio or resistance in a third of a second, V24 measures DC voltage and voltage ratio at same speed . . . both instruments feature advanced transistoried circuitry and mercury-wetted relays with life in excess of 3 billion readings . . . ±one digit accuracy on DC voltage and voltage ratio . . . completely automatic operation . . . plug-in modular construction . . . AC or low level measurements with plug-in accessories . . . output connectors for continuous data logging. Ranges: DC voltage ±.0001 to ±999.9; DC voltage ratio to ±.9999; resistance .1 ohm to 1 megohm. M24, complete: $5,650.00. V24, complete: $4,950.00. Write today for complete data.

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NEW . . . FREE 20-page Series 20 booklet, most complete ever offered on a single DVM series.

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ENGINE CONTROLLER

New Control System for automatically starting, loading, and shutting down internal combustion engines is pneumatically actuated. Inherently explosion-proof, its building-block concept provides maximum versatility. Temperatures, pressures, liquid levels, vibration, and engine speeds are monitored continuously.—*Fulton-Sylphon Div., Robertshaw-Fulton Controls Co., 911 East Broad St., Richmond 19, Va.*

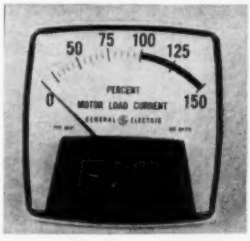
CIRCLE 223 ON READER-SERVICE CARD

COMPRESSION TESTER

New Compression Tester, Style CT-10-468, is capable of exerting 10,000 psi pressure. Platens are 48" wide, 72" long. An a-c/d-c generator-type drive motor makes possible infinite varying speed down to 0.100" min. Electronic weighing and recording is made possible through the use of a load-cell system with an electronic recorder.—*Gaynes Engineering Co., 1648 West Fulton St., Chicago 12, Ill.*

CIRCLE 224 ON READER-SERVICE CARD

MOTOR LOAD INDICATORS



New line of Motor Load Indicators is made in a-c models, supplied as either ammeters, which measure percent of motor load current; or wattmeters, measuring percent of horsepower. Available for single- and three-phase, 50- or 60-cycle motors. D-c instrument, an ammeter design, measures d-c motor input current. Sizes are: a 3½" panel meter (with 2% accuracy), and 4¼" and 8¾" switchboard instruments (with 1% accuracy).—*General Electric Co., Schenectady 5, N. Y.*

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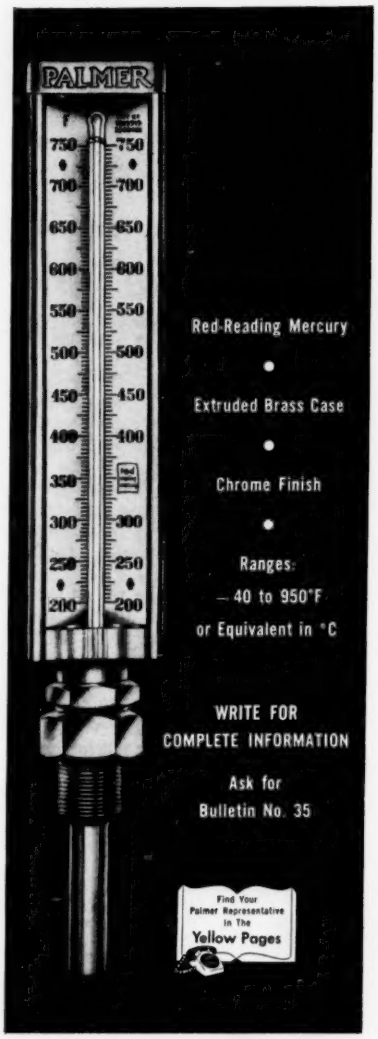
TODAY'S MODERN INDUSTRY DEMANDS A MODERN THERMOMETER

PALMER

RED-READING MERCURY THERMOMETERS



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RUGGED "All Purpose" X-Y RECORDER

The HR-92 is a null-seeking servo-type plotter designed to draw curves in Cartesian coordinates on regular 8½ x 11 graph paper. Control panel has zero set and continuously-variable attenuator for each axis. Separate standby and power switches are provided. Two axes are electrically and mechanically independent.

- Amplifiers easily removed if servicing ever becomes necessary. Electrical connections all contained in two plugs for each amplifier.
- Each amplifier channel (including transformer power supply) independent of rest of system.

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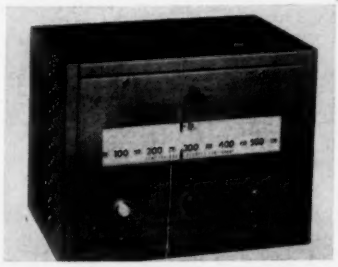
MINIATURIZED RESISTORS

New line of Blue X-60 Series Resistors is made of a wire-wound fibreglass core to which lead and clip assemblies are accurately crimped. Then the entire assembly is placed in a ceramic enclosure which in turn is filled with a silicone base cement that provides maximum protection against moisture.—*Tru-Ohm Products, Div. of Model Engrg. and Mfg. Inc.*, 2800 *N. Milwaukee Ave., Chicago* 18, *Ill.*

CIRCLE 226 ON READER-SERVICE CARD

TEMPERATURE CONTROLLER



New Series 5000 Indicating Temperature Controller features a 10″ slide rule readout based on a rugged stable null balance servo system. Available with either time-proportioning or on-off control, with or without anticipating section. Control stability of the proportional model with anticipating section has been achieved to ±0.1°F, and to ±0.5°F with the on-off model with anticipation. Indication accuracy is ±½% of scale range.—*Electronic Processes Corp.*, 436 *Bryant St., San Francisco* 7, *Calif.*

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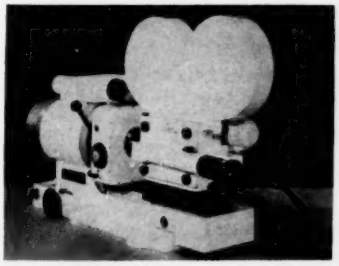
35 mm BORESIGHT CAMERA



New Model IBDM-20 Cameraflex Camera, a radar-antenna-mounted Bore-sight Camera to obtain pictures and data for calibration, tracking error correction, engineering sequential and documentary use, features reflex-type viewfinder, with boresight reticle; variable shutter calibrated in degrees, illuminated fiducial markers, three-track optical data recorder; 20 frames/sec (up to 48 frames per second with change of drive gears.); aperture size of 0.748″ x 0.868″, etc.—*Federal Mfg. and Engrg. Corp., Garden City, N. Y.*

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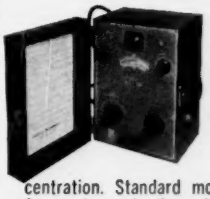
ELECTROLYTIC CONDUCTIVITY EQUIPMENT

CONDUCTIVITY BRIDGES



Industrial Instruments offers a **complete** line of electrolytic conductivity bridges for the measurement and control of solution concentration. Standard models are available for use in conductive solutions ranging from distilled water to concentrated acids or alkalis, and in all temperature ranges.

CONDUCTIVITY CONTROLLERS

For steam generation, water purification, chemical processing general lab work, and wherever continuous indication and/or control of solution conductivity is required Industrial Instruments has a wide line of practical instruments designed specifically for the job. Also available are conductivity recorders in circular and strip-chart, single and multi-point types as well as battery-operated units.

CONDUCTIVITY CELLS

A single source for all your cell needs. Body materials in the widest range of materials to meet every requirement for temperature, pressure and corrosion resistance. Complete selection of cells designed to meet your application requirements... no universal compromises. Nickel platinum, graphite, gold or tin electrode materials as well as a comprehensive selection of cell constants and ranges for every measurement application.

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With Wallace & Tiernan Aneroid Dial Indicators you get precision and fast response in all types of absolute pressure work.

W&T Precision Indicators have many uses in research and development engineering. One is ideal for calibrating pressure transducers; another, for checking the calibration of flight instruments and ground support equipment. These instruments also keep constant check on continuous production-line work.

A W&T Absolute Pressure Gauge on the job means:

- ★ Accuracy 0.1% to 0.33%
- ★ Sensitivity 0.01% to 0.2%
- ★ Range 0.1-20 mm Hg to 0-500 p.s.i.a
- ★ No corrections
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The accuracy of W&T Absolute Pressure Indicators approaches that of liquid columns... higher sensitivity assures faster response... large dial gives quick reading.

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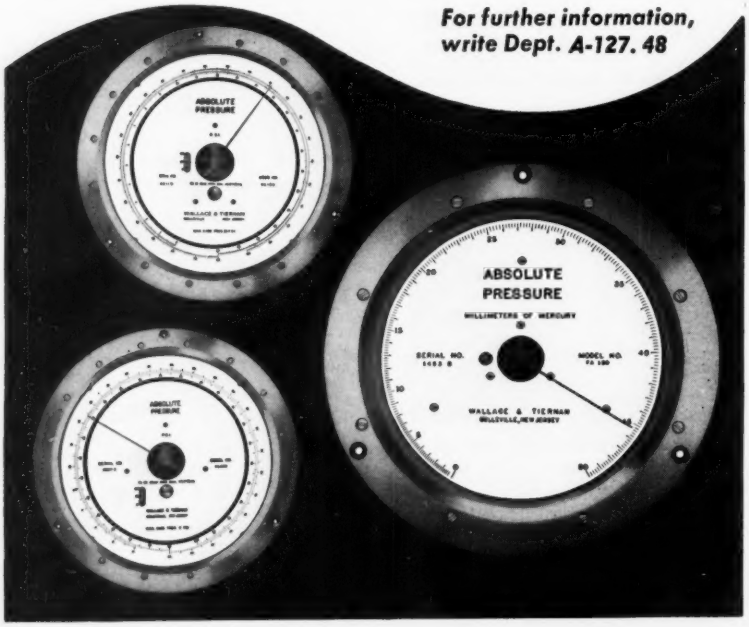

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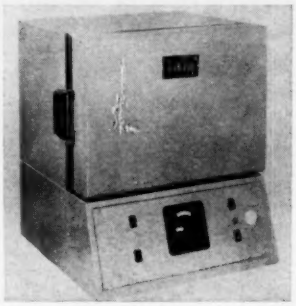
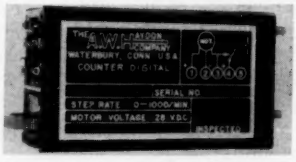
TEMPERATURE CHAMBERS



New Environmental Test Chambers, Series HL, operating from −100° +600°F are cooled with liquid CO_2. Rapid pulldown enables shock testing. Available in 4 sizes from 1 to 8-cu-ft working capacity. Chambers are bench models, fully sealed against moisture, and equipped with silicone door gaskets. Bulletin gives details.—*Gruenberg Electric Co., Inc., 9 Commercial Ave., Garden City, N. Y.*

CIRCLE 229 ON READER-SERVICE CARD

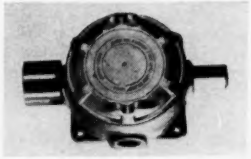
READOUT TIMING DEVICES



New line of precision Stepping Devices, Series 18200, featuring digital-counter or dial readout, includes predetermined and remotely settable pulse counters and interval timers which operate only on the number of pulses received, not incremental changes in voltage or phase angle. Conform to MIL-E-5272C specs.—*A. W. Haydon Co., 232 North Elm St., Waterbury, Conn.*

CIRCLE 230 ON READER-SERVICE CARD

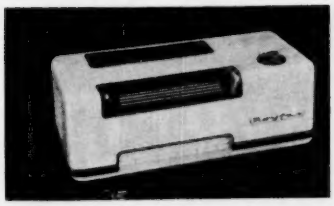
PRESSURE CONTROLLER



New dual-switch, explosion-proof Pressure Controller, Model H98A, permits control of two independent circuits to simulate double-pole circuitry. Several models are available with calibrated ranges between 20 and 1700 psig, with proof pressures of 2500 psig and maximum pressures of 3500 psig. Suitable for Class I, Group C and D; Class II, Group E, F and G and Class III.—*United Electric Controls Co., 79 School St., Watertown, Mass.*

CIRCLE 231 ON READER-SERVICE CARD

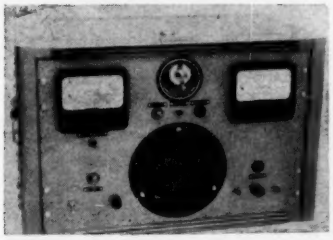
OFFICE COPIER



New Royal Royfax Office-Copier reproduces documents at a rate of up to 100 or more copies an hour from any type of orginal, regardless of color, such as pen or pencil copy, blueprint, and hectograph copies employing the light diffusion process, Priced in the same range as the average office typewritter (approximately $220) and can be operated by any office employee.—*Royal McBee Corp., Westchester Ave., Port Chester, N. Y.*

CIRCLE 232 ON READER-SERVICE CARD

CAPACITOR CHARGING POWER SUPPLY



New Model K20-0.5 Capacitor Charging Power Supply for wind tunnel charging, for linear accelerators in atomic research, and similar applications, which charges a 500-mf capacitor to 20,000 v in two minutes, and does this every two minutes, features a low-resistance, heavy-duty rectifier providing 4 kw of instantaneous power. Consists of remote control cabinet (shown) and high-voltage section interconnected by cable.—*Peschel Electronics, Inc., Towners, Patterson, N. Y.*

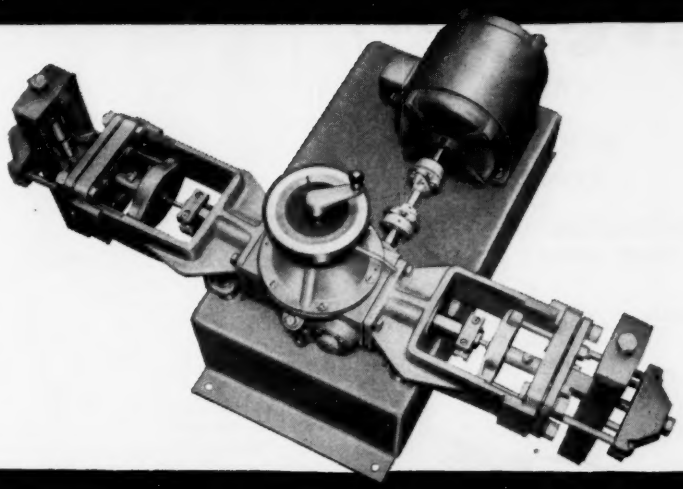
CIRCLE 233 ON READER-SERVICE CARD

WIDE ANGLE READOUT

New Frequency Counters feature an in-line display with all digits formed on the surface plane. Digits, 1½" high, are colored bright red so that the display is clearly visible in high ambient light.—*Berkeley Div., Beckman Instruments, Inc.*, 2200 *Wright Ave., Richmond, Calif.*

CIRCLE 234 ON READER-SERVICE CARD

We Researched Over 15 Industries



Before We Designed This New Pump

From Maine to Texas we explored refineries, paper mills, pharmaceutical and chemical plants. Everywhere we found that metering operations—from pilot plants to proportional blending—were automated, efficient, ingenious. But there was room for an improved plunger pump. A pump that would give more flexibility and convenience in modern metering operations . . . positive accuracy and dependability in metering bland or harshly corrosive liquids against pressure.

Because it's designed around these critical needs, the new Wallace & Tiernan Series 200 Metering Pump fills the bill. Here's how:

Flexibility Drive units may be ganged to meter several liquids. One, two, or three liquid ends on one drive increase capacity and smooth out pumping pulsations. Six stroking speeds, several plunger diameters, and many liquid-end materials add further flexibility. "Stop-Adjust" and "Run-Adjust" models are available. On the latter, automatic stroke-length control, including ratio control, is easily achieved.

Convenience For different capacities or liquids, self-aligning liquid ends are quickly changed as complete units—a real convenience in pilot plant study. Bases for the Series 200 Pump may be steel plate, pipe, or structural shapes. A unique arrangement of eccentrics drives the plunger. This eliminates rocker arms and makes for the responsive, convenient stroke-length control industry needs.

Dependability The Series 200 Pump's design and materials mean resistance to wear and corrosion, less maintenance, and dependable operation. The drive is powered by a standard electric motor. Heavy ball bearings, forced-feed lubrication, and no cantilever bearing loads also assure long-lasting dependability.

Accuracy The Series 200 Pump meters accurately against up to 4,000 psi in the lower ranges (minimum 0.65 gph). And it meters any set amount, time after time, within ±1%—the kind of accuracy modern quality-controlled blending must have.

In every feature, the new Series 200 Pump is designed with modern industrial processing in mind. Component by component and feature by feature, you, the industrial user, called the shots. You specified the new W&T Series 200 Metering Pump.

For more on this user-inspired pump, write today to Dept. L-5.48.

WALLACE & TIERNAN INCORPORATED

25 MAIN STREET BELLEVILLE 9, NEW JERSEY

CIRCLE 105 ON READER-SERVICE CARD

2888

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AUTOMATIC CONTROL

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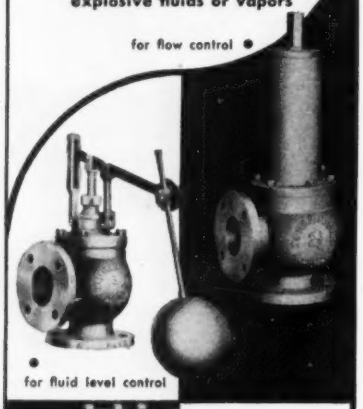
of

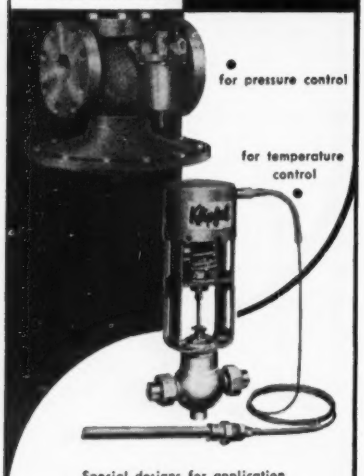
STEAM • GAS • AIR • WATER

viscous or abrasive sludges

CHEMICALS

explosive fluids or vapors





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HAMILTON, OHIO

A DIVISION OF THE HAMILTON-THOMAS CORPORATION

CIRCLE 106 ON READER-SERVICE CARD

GAS/AIR RECIRCULATOR

New Recirculating Molecu-Dryer, Type MS-R, has an atmosphere recirculating unit using adsorptive 5A Molecular Sieve material. It furnishes pure dry air, with dew points to —100°F or lower. The recirculator employs a positive-acting air blower, and an aluminum fin-type after-cooler which removes the heat of compression from the air stream. Seven standard factory-built models are available with capacities to 20,000 cfh.—*C. I. Hayes, Inc.*, 944 *Wellington Ave., Cranston* 10, *R. I.*

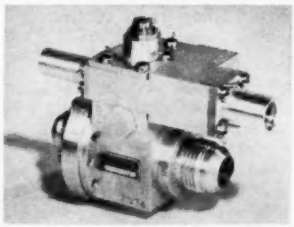
CIRCLE 235 ON READER-SERVICE CARD

RECTILINEAR TRANSDUCER

New series of subminiature, variable-permeance Type ZD Transducers is primarily used as a position sensor for analytical balances, automatic scale beams, and small meter movements. Three models are presently available in rated ranges of 0.10" to 0.80" displacement. Bulletin gives details.—*Crescent Engineering and Research Co.*, 5440 *North Peck Rd., El Monte, Calif.*

CIRCLE 236 ON READER-SERVICE CARD

BALL VALVES



New low-torque Ball Valves feature zero leakage. Operating up to 10,000 psig they can be furnished with pneumatic, hydraulic, electric, or manual actuators. Models are available for handling helium, liquid oxygen, red fuming nitric acid, hydrogen peroxide as well as the normal fluids used in power and propulsion equipment.—*Pneu-Hydro Valve Corp.*, 52 *Horse Hill Rd., Cedar Knolls, N. J.*

CIRCLE 237 ON READER-SERVICE CARD

A NEW ADDITION to MERCOID PRESSURE CONTROLS

316 STAINLESS STEEL

Welded Bourdon Tube and Pressure Connection

Series D-41, 243, 541

316 stainless steel welded Bourdon tube. ¼" (316) stainless steel pressure connection. Nickel plated mechanism. Outside adjustments. Calibrated dial. Hermetically sealed mercury contact.

Operating ranges: 30" vac.-75 psig; 10-100 psig; 30-400 psig; 75-800 psig. and 100-1000 psig.— with varying differentials and electrical capacity to meet your application.

Three case styles: General Purpose NEMA 1; Weather-Proof NEMA 1A, 2, 3, 4; Explosion-Proof Class 1 Group C, & D; Class 2 Group E, F, G, NEMA 7, 9, 9A.

WRITE FOR BULLETIN 019

THE MERCOID CORPORATION

4211 Belmont Ave., Chicago 41, Ill.

CIRCLE 107 ON READER-SERVICE CARD

DIGITAL VOLTMETER

New low-cost d-c Digital Voltmeter, Model V-1, converts an unknown voltage into decimal numbers with an accuracy of 0.5% of full scale. Featuring high speed response (1/24 sec for full scale), it is small in size (6¾" high x 4⅜" wide x 9" deep). Available in three ranges 0-2.5 v, 0-25 v and 0-250 v.—*Electro-Logic Corp., 515 Boccaccio Ave., Venice, Calif.*

CIRCLE 238 ON READER-SERVICE CARD

LOAD INDICATOR

New Model DLI-6R Load Indicator reads out six strain gage load cells. Each of the six inputs has its own zero and span control so that each load cell can be zeroed and its span adjusted independently of the others. The indicator is of the servo-null balance type with digital readout providing a reading of 0.1% without need for interpolation. It is provided with transistor-regulated d-c power supply for the load cells.—*Performance Measurements Co., 15120 Third Ave., Detroit 3, Mich.*

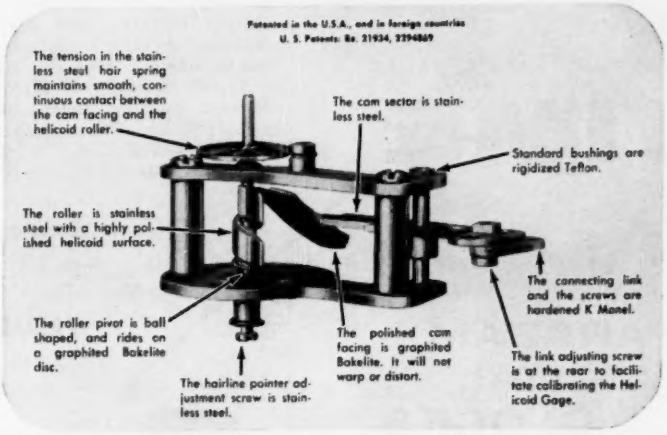
CIRCLE 239 ON READER-SERVICE CARD

MINI BLACK BODY SOURCE

New Model P-E 521-6 Miniature Infrared Source, which provides accurately adjustable source of infrared radiation when used with the Model P-E 531-5 Temperature Controller, is designed to calibrate the seeking head of infrared guided missiles and other infrared sensitive elements in the 200° and 600° temperature range.—*Perkin Elmer Corp., Norwalk, Conn.*

CIRCLE 240 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DH-65**

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ACCO

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CIRCLE 108 ON READER-SERVICE CARD

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to investigate
PARABAM DIGITAL CLOCKS

The Parabam Digital Clock provides accurate time-of-day for...

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- ★ PROCESS CONTROL
- ★ DATA PROCESSING
- ★ COMPUTING SYSTEMS
- ★ TEST DATA RECORDING

up to 86,400 contact combinations.

- Time-of-day readings in increments of one minute, tenth-minute or one second.
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- Single plane, in-line lamp bank display. 1" high numerals. (Display also available for remote mounting.)
- 24 hour or 12 hour AM-PM configurations.

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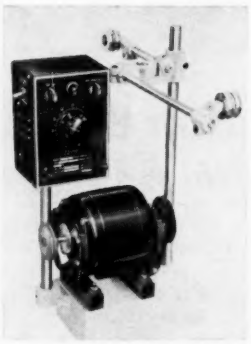
CIRCLE 109 ON READER-SERVICE CARD

PACKAGED CONTROL PANELS

New Protectal packaged control panels; for automatic start, stop, and complete combustion supervision of gas-fired ovens, furnaces, boilers, various heating and heat-treating systems; include a starter for 3-hp motor, circuit breaker, combustion safeguard, control circuit transformer, purging timer, etc. Units meet FM and FIA standards.—*Protection Controls, Inc.*, 7317 *N. Lawndale Ave., Skokie, Ill.*

CIRCLE 241 ON READER-SERVICE CARD

VARIABLE MOTOR DRIVE

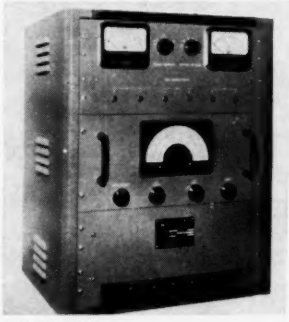


New Motor Drive Unit Model ACAZ or Model ACAY which provides a continuously variable spindle speed from 0 to 4000 rpm, containing no tubes, features starting and stopping by means of a foot operated switch which also operates a coolant pump when it is used. Unit is for 110 v 60 cycle/1-phase a-c current and contains full overload protection.—*Louis Levin & Son, Inc.*, 3610 *So. Broadway, Los Angeles 7, Calif.*

CIRCLE 242 ON READER-SERVICE CARD

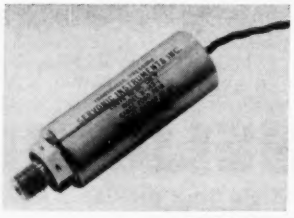
ELECTRONIC GENERATOR

New Model 1451-B Electronic Generator is made in fixed-frequency models, available from 400 to 2000 cps, with two standard variable ranges (1) 350 to 450 cps, and (2) 1400 to 1800 cps. Maximum power output is 170 va per phase or 500 va total as a three-phase unit. Rated power is delivered by this generator into loads from unity to 0.8 power factor. Regulation is within 2%, no load to full load, with steady stable stability of ±0.2%.—*Communication Measurements Lab., Inc.*, 352 *Leland Ave., Plainfield, N. J.*



CIRCLE 243 ON READER-SERVICE CARD

HI-PRESSURE TRANSDUCER



New H-143 High-pressure Transducer features all-welded construction, high vibration performance, low weight, and meets a total dynamic error band of ±2%. Available in pressure ranges between 1,000 and 5,000 psig.—*Servonic Instruments, Inc.*, 640 *Terminal Way, Costa Mesa, Calif.*

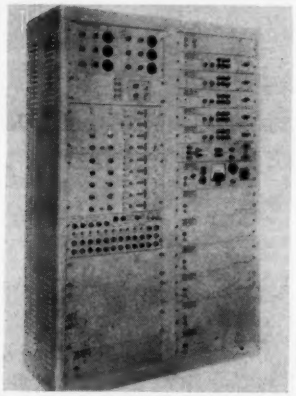
CIRCLE 244 ON READER-SERVICE CARD

TAPE PLOTTING SYSTEM

New digital Magnetic-tape System, Type 575, which permits plotting of digital computer results in continuous-curve form on an X-Y- recorder, includes a digital tape transport, a digital magnetic tape translator, tape control unit, record-playback amplifiers, and an Autograf X-Y recorder. Computer tape speed is 75 or 112.5"/sec. The tapes are played back on a slow-speed 3"/sec tape transport for recording on conventional X-Y charts. Few controls are needed as complicated tape editing and digital "computing" hardware have been replaced by decks of IBM cards. Accuracy of the dig/an conversion is better than ± 0.1% of full scale. The translator is completely transistorized and features illuminated visual display, automatic parity checking and automatic search mode.—*F. L. Moseley Co., 409 North Fair Oaks Ave., Pasadena, Calif.*

CIRCLE 245 ON READER-SERVICE CARD

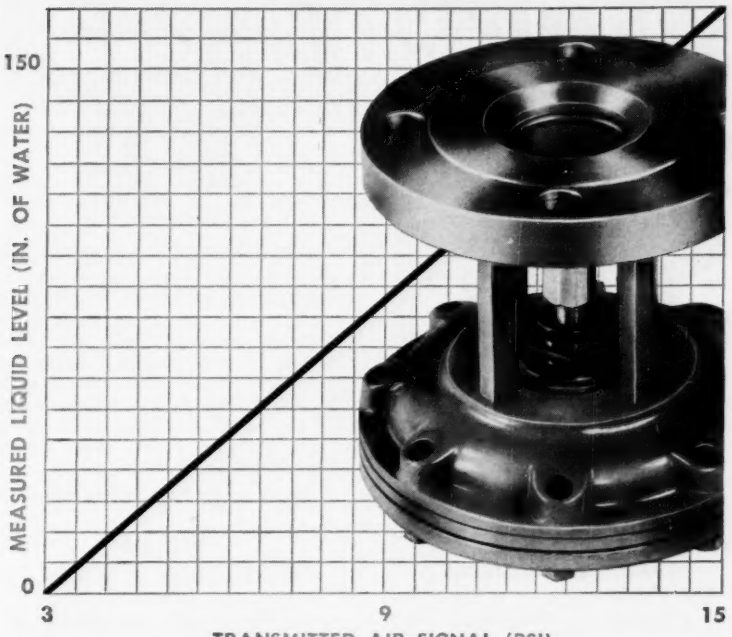
MEMORY CORE TESTER



New Automatic Memory Core Tester, Type 2101, is a high-speed production-line core tester that automatically sorts a run of cores into several categories of precise specification. A full range of specifications can be programmed into the tester's decision-making logic which makes up to seven "accept-reject" decisions on core amplitude, measured by two highly stable linear calibrated sense amplifiers.—*Digital Equipment Corp., Maynard, Mass.*

CIRCLE 246 ON READER-SERVICE CARD

TYPICAL PERFORMANCE CURVE OF MODEL "P" TRANSMITTER



LOW COST PRESSURE AND LIQUID LEVEL TRANSMITTER WITH QUALITY FEATURES FOR DEPENDABLE OPERATION

The Conoflow Model "P" Transmitter is a low cost, rugged instrument which measures pressure and liquid level and transmits a *linear* 3-15 psi signal to standard receiver elements. Incorporates many features not found in more expensive devices for guaranteed dependable operation.

Safety—Process liquids and gases cannot back up into air lines and damage costly instruments. This is assured by the complete separation of measuring diaphragm from pneumatic pilot.

Simple Installation—The Model "P" can be mounted either horizontally or vertically on open or closed vessels. No dip tubes, floats or other mechanical devices are required inside the tank.

Long Life—Only the corrosion-resistant *Inconel X* diaphragm is exposed to the measured material. Preformed diaphragm will not work-harden or fatigue; withstands pressures to 500 psi and temperatures to 450°.

Versatile—Can be used for practically any service; ideal for viscous fluids or materials with solids in suspension; also for flowing bulk materials such as pigments, flakes, etc.

Choice of Ranges—Available for measuring ranges as low as 0 to 100" of water and pressures as high as 250 psi. Ranges can be changed in the field.

Specifications—New Bulletin P-36-1 contains complete specifications on the Conoflow Model "P" Transmitter. Write for your copy today or ask for a quote. No obligation. Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Pa.

CC-1003

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FOREMOST IN FINAL CONTROL ELEMENTS
SUBSIDIARY WALWORTH

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UNSURPASSED QUALITY AT REGULAR MILL PRICES

.010" O.D. to 1.125" O.D.

Copper, Brass, Bronze

● Why play checkers jumping from one supplier to another for better "buys" and better quality? You'll find your ultimate answer in the temper, straightness, roundness and size tolerances of Precision Tubing.

Precision Tubing is carefully tested and pre-tested in every step of production. Skilled craftsmen using modern drawing equipment and dies which are "quality-controlled" in our own shop assure Nth degree accuracy in every foot of tubing drawn. Electronically controlled annealing produces tubing to meet your most exacting specifications.

Precision also makes round, rectangular, Bourdon, oval or square, preformed to special shapes . . . in copper brass, aluminum, nickel and nickel-alloys, Ni-Span "C", phosphor-bronze and nickel silver.

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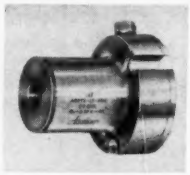
CIRCLE 111 ON READER-SERVICE CARD

NEW INSTRUMENTS

SAMPLING VALVE



New Sampling Valve No. SV-700 delivers perfect live samples, not affected by settlement or clogging owing to the s.-s. piston which, in closed position, completely fills the valve body and extends to inner surface of the vessel. Made with pipe threads, ¾" male inlet and ½" female discharge. Detailed information in bulletin.—*Strahman Valves, Inc., Nicolet Ave., Florham Park, N. J.*

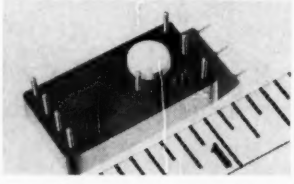
CIRCLE 247 ON READER-SERVICE CARD

ANALOG INTEGRATOR NETWORKS

New Series of operational-amplifier Integrator Networks, consisting of from one to 18 output branches and feedback (integrating) capacitor in an oil-filled hermetically-sealed can feature high level of accuracy and stability over wide ranges temperature.—*Julie Research Labs., Inc., 556 W. 168th St., New York 32, N. Y.*

CIRCLE 248 ON READER-SERVICE CARD

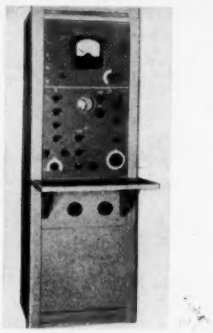
MINI ENCAPSULATED NOR LOGIC CIRCUIT



New Dalohm Balanced Resistor Network, Model SPR-76, measuring only 1¼" x $\frac{11}{16}$" x ¼" contains five precision wire-wound resistors and one transistor, incorporated into a NOR logic circuit. Complete circuit is encapsulated in a rigid epoxy compound. The network is designed to withstand tough moisture, temperature-cycling, vibration, and life tests. —*Dale Products, Inc., Columbus, Neb.*

CIRCLE 249 ON READER-SERVICE CARD

HI-VOLT SCHERING BRIDGE



New High-Voltage Schering Bridge is available as a General Purpose Bridge and also as a Cable Test Bridge for measuring the power factor and capacitance of electrical insulating materials while subjected to high voltage stress. Both units feature an extremely wide capacitance range (General Purpose Bridge from 0.0000025 to 1.0 μf; Cable Test Bridge from 0.0000025 to 2.0 μf) and built-in shunts for testing large capacitances without the need for additional equipment. Capacitance accuracy is $\pm 0.2\%$ and tangent accuracy is 2.0% or better.—*Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, N. J.*

CIRCLE 250 ON READER-SERVICE CARD

FREED
VARIABLE TEST VOLTAGE MEGOHMMETER NO. 1620

The Freed Type 1620 Megohmmeter is a versatile insulation resistance measurement instrument with a continuously variable DC test potential from 50 to 1000 volts.

Components such as transformers, motors, printed circuits, cables and insulation material can be tested at their rated voltage and above, for safety factor.

- **Resistance — 0.1 megohms to 4,000,000 megohms.**
- **Voltage — variable, 50 - 1000 volts.**
- **Accurate — plus or minus 5% on all ranges.**
- **Simple — for use by unskilled operators.**
- **Safe — high voltage relay controlled.**
- **Self contained — AC operated.**

OTHER MEGOHMMETERS AVAILABLE

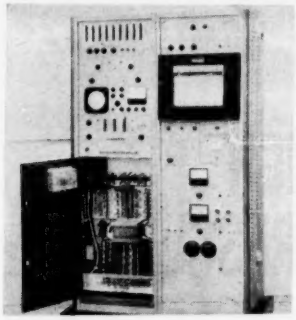
Type 1620C MEGOHMMETER — a type 1620 with additional circuitry for testing capacitors.
Type 1020B MEGOHMMETER — a 500 volt fixed test potential. Range 1 megohm to 2 million megohms.
Type 2030 PORTABLE MEGOHMMETER — battery operated 500 volt test potential. Range 1 megohm to 10 million megohms.

Send for NEW 48 page transformer catalog. Also ask for complete laboratory test instrument catalog.

FREED TRANSFORMER CO., INC.
1707 WEIRFIELD ST., BROOKLYN (RIDGEWOOD) 27, N.Y.

CIRCLE 112 ON READER-SERVICE CARD

256-CHANNEL ANALYZER



New 256-Channel Analyzer, Model 20613, features pre-selected automatic programming; magnetic tape auxiliary memory; 600-2500 v. high voltage power supply; single-push button manual operation; and six modes of readout. Desired analyzer cycle can be pre-programmed on functional programming patchboard.—*Radiation Counter Labs., Inc.*, 5121 *W. Grove, Skokie, Ill.*

CIRCLE 251 ON READER-SERVICE CARD

PARTICLE MONITOR

New Atmospheric particle Counter, Model PG-200, continuously monitors outdoor air or atmospheres of indoor locations, such as ultra-clean work areas. A strip-chart recorder registers aerosols present in an overall range from 0.3 μ to any desired upper limit. Counting rate of the PC-200 is 1000 particles/min with a 1% coincidence loss at the standard flow rate of 100 cc/min.—*Royco Instruments Inc.*, 365 *San Antonio Rd., Mountain View, Calif.*

CIRCLE 252 ON READER-SERVICE CARD

TRANSISTOR INDICATOR LAMP

New high-impedance low-voltage miniature transistorized incandescent Indicator Lamp eliminates high-voltage power supply of transistorized neon-type indicators and features the addition of a second transistor which serves as a driver to provide a high-input impedance. Indicators are available for either positive or negative 6-, 8-, or 10-v supply sources at 50 ma. The assembly has ½" dia x 2" length with a Type GE-345 incandescent lamp.—*C & K Components, Inc.*, 103 *Morse St., Newton* 58, *Mass.*

CIRCLE 253 ON READER-SERVICE CARD

HEISE GAUGES

Something More Than

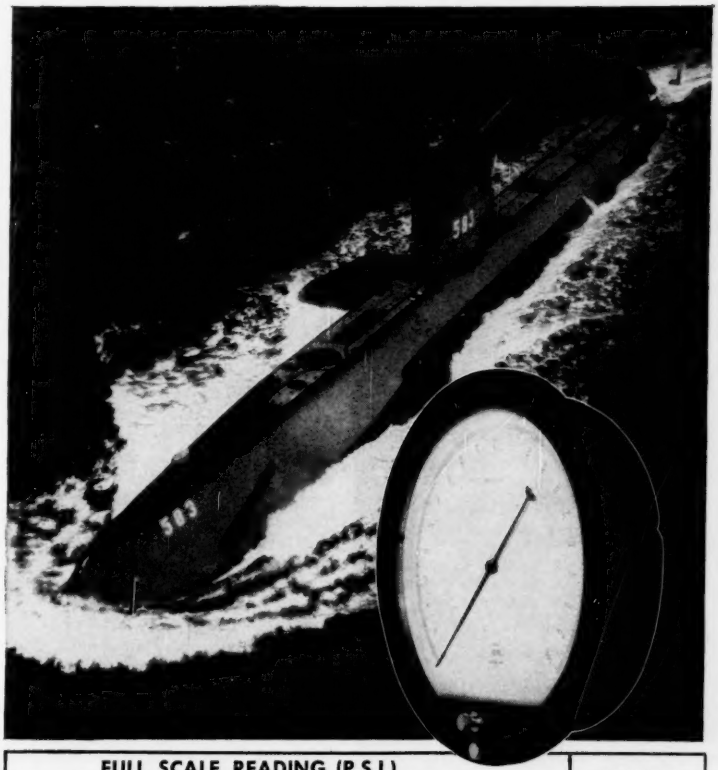
"COMMERCIAL INSTRUMENTATION"

Standards of accuracy for instruments used in testing reactor plants in nuclear powered submarines may be achieved only by superior design and scrupulous workmanship.

The Heise Bourdon Tube Company provided pressure gauges used in initial tests of the power plant designed for the USS Nautilus, the first atomic powered submarine.

Heise Gauges were also used during initial testing of reactor plants on the atomic powered submarines, Skipjack, Skate, Swordfish, and Sargo.

Heise Laboratories design and manufacture pressure measuring instruments for the most advanced research and development projects.



FULL SCALE READING (P.S.I.)						DELIVERY 2 WEEKS FOR MOST RANGES
OVER	15	5,000	20,000	30,000	40,000	
INCLUDING	5,000	20,000	30,000	40,000	50,000	
DIAL SIZE	PRICE F.O.B. NEWTOWN, CONN.					
8½"	$166.75	$186.75	$216.75			
12"	$190.50	$210.50	$240.50	$250.50	$260.50	
16"	$232.25	$252.25	$282.25	$292.25	$302.25	

HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

CIRCLE 113 ON READER-SERVICE CARD

NEW

DC driven CHOPPERS

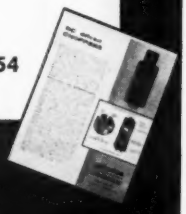
No AC!

For battery-operated portable low-level d-c amplifiers

and

For transistorized d-c amplifiers. Removes stray a-c signals from chassis wiring. Eliminates null offsets.

Write for Catalog 554



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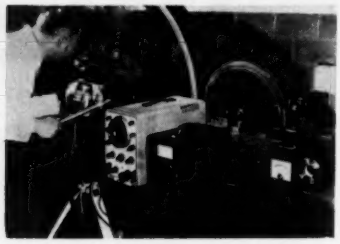
CIRCLE 114 ON READER-SERVICE CARD

NEW INSTRUMENTS

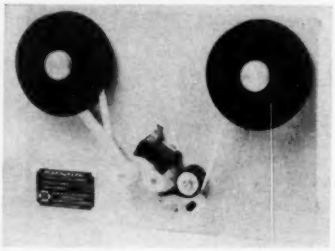
RADIATION THERMOMETER



New Thermodot Radiation Thermometer (Radiometer), primarily for industrial testing, inspection, and quality control, measures the surface temperature of pieces rotating at high speed on a test stand. Thermal patterns are displayed on an oscilloscope for direct observation and photographic recording. Using a mirror system within the optical head to focus this radiation a sensitive generates a signal voltage which is amplified. Time constant is two msec for continuous measurements and ten μsec for transient measurements. Temperature range is from 100°F to 8,000°F. —*Radiation Electronics Co., Div. of Comptometer Corp.*, 5600 *Jarvis Ave., Chicago* 48, *Ill.*

CIRCLE 254 ON READER-SERVICE CARD

DIGITAL DATA RECORDER



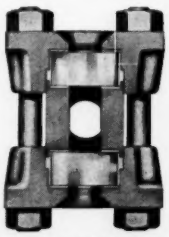
New Perfograph Digital Data Recorder records information on a variety of physical quantities in digital form (up to eight channels and any digital coding may be accommodated) on a narrow paper tape by perforating it electronically with patterns of small holes. The data can later be interpreted automatically by a photoelectric tape reader at a data processing center. The portable unit, which operates for several months on small dry batteries, is the heart of a complete system for machine-acquisition, storage, transmission and reduction of data, which uses custom input transducers to measure and put into digital form wind speed and direction, temperature, pressure, meter readings, numerical count of items, etc. Special high-speed recorders have been developed for missile applications and other military requirements. —*Advanced Instrument Corp.* (*Advinco*), 700 *South 4th St., Richmond, Calif.*

CIRCLE 255 ON READER-SERVICE CARD

Strahman

HIGH PRESSURE GAUGES

USED IN
REFINERIES
AND
CHEMICAL PLANTS
THROUGHOUT THE WORLD

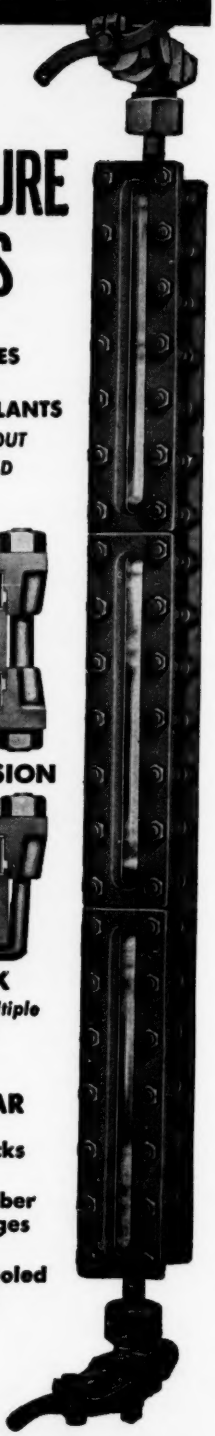


THRU VISION

REFLEX
Single or Multiple Sections

TUBULAR

Gauge Cocks
•
Large Chamber Reflex Gauges
•
Heated or Cooled Gauges



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COMPLETE CATALOGUE

STRAHMAN VALVES, Inc.
NICOLET AVE., FLORHAM PARK, N. J.

CIRCLE 115 ON READER-SERVICE CARD

VARIAN
Temperature
RECORDERS

Most versatile and useful because . . .

6. THEY'RE PORTABLE AND

MULTI-RANGE

Nine plug-in elements adapt this G-11A thermocouple recorder to any range — cold as liquid nitrogen, hot as 2200°F, or as specific as 30° to 220°F. Being portable, it goes wherever there's temperature to measure — research in the lab, checkout in the factory, or troubleshooting in the field.

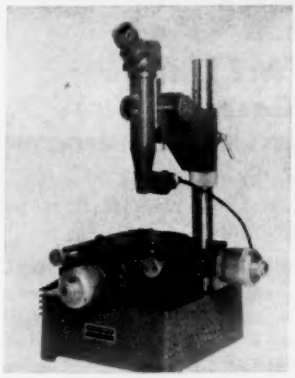
The temperature recorder is a Varian G-11A with T-2 input chassis which has automatic reference junction compensation and plug-in range elements as shown. Other input chassis convert the recorder to general use. Fahrenheit or Centigrade charts available. For full details, write Instrument Division.

VARIAN associates

PALO ALTO 27, CALIFORNIA

CIRCLE 116 ON READER-SERVICE CARD

TOOLMAKER MICROSCOPE



New model Leitz Simplex Toolmaker Microscope has no tilt of the tube to the helix angle, but features a 360° rotary stage to permit measurements in polar coordinates. Total range is 2" x 2" with direct micrometer readings in 0.0001".—*Opto-Metric Tools, Inc.*, 137 *Varick St., New York* 13, *N. Y.*

CIRCLE 256 ON READER-SERVICE CARD

HI-TEMP THERMOCOUPLES

New types of thermocouples, said to have outstanding stability in high-temperature measurements, are usable above 3000°F, the maximum temperature which the most resistant of conventional thermocouples can withstand. These rhodium-iridium/iridium and tungsten/rhenium couples promise to be highly useful in vacuum or inert/atmospheres, and particularly oxydizing atmospheres, up to 3600° F.—*Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Wayne & Windrim Aves., Phila.* 44, *Pa.*

CIRCLE 257 ON READER-SERVICE CARD

SOLID-STATE AN/DIG CONVERTER

New solid-state analog-to-digital Converter, Multiverter M3, which has a speed of 10,000 conversion/sec with 0.05% accuracy is available either with 11-bit binary, 3-digit BCD plus sign standard, or with 4 decimal digits plus sign on special order. Completely transistorized and small in size (19" x 16" x 5¼") it requires only 35 w power of 115/230 vac, 50-400 cps. Input impedance is optional and therefore absolutely specified at 10,000 ohms/v.—*Packard Bell Computer*, 1905 *Armacost Ave., Los Angeles* 25, *Calif.*

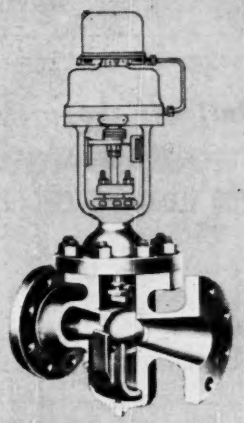
CIRCLE 258 ON READER-SERVICE CARD

General Kinetics Corp.

P-K PAUL CONTROL VALVES OFFER

***Less* DOWN TIME for MAINTENANCE and REPAIR**

In the most critical applications the unique Venturi-ball design of the P-K Paul Valve has consistently surpassed conventional valves in uninterrupted hours of operation. Since the ball of the P-K Paul Valve presents an infinite number of contact surfaces to the metal seat, down time caused by erosion, abrasion and wire-drawing is reduced to an absolute minimum.



- High Flow Capacity
- Wide Rangeability
- Positive Shut-Off
- Non-Turbulent Flow
- Low Operating Thrust
- Self-Purging
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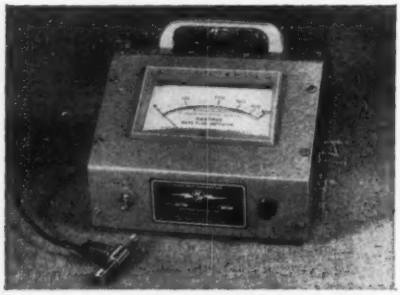
MASS FLOWMETER
For Air and Gases

DIRECT READINGS INDEPENDENT OF PRESSURE AND TEMPERATURES

Calibrated directly in milligrams of air per minute. Especially well suited for measuring low rates of flow. Gives direct, continuous readings, holds calibration indefinitely, has low power requirements.



Hastings Model SM-1 Mass Flowmeter
Range: 0 - 500 milligrams of air per minute

HASTINGS MODEL SM-1 MASS FLOWMETER
Range: 0 - 500 milligrams of air per minute. Relatively linear scale. Large mirror scale assures highest accuracy and easier readability. Ideal for remote indicating recording.

HASTINGS MODEL MF-1 MASS FLOWMETER
Range: 0 - 10,000 milligrams of air per minute. Highest accuracy and sensitivity at low flow ranges. Maximum readability for air flows in range from 50 - 1,000 milligrams per minute.

COMPLETE LINE OF INDUSTRIAL, COMMERCIAL, AND LABORATORY INSTRUMENTS.
AIR METERS • JET VANES • WIND VELOCITY RECORDERS • AIR DRIFT INDICATORS
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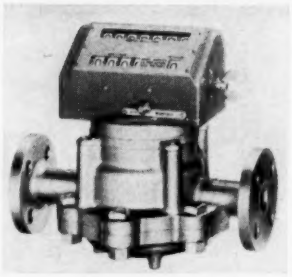
VOLTAGE-TO-FREQUENCY CONVERTER

New Model 240A Converter includes fully transistorized circuitry which develops a frequency precisely proportional to input voltage with 0.1%

long-term accuracy. Frequency range is 0-100 kc. Full-scale sensitivity can be switched from 0.1 v through 1000 v in five steps. Three package designs are available: rackmount requiring only 3½" of standard 19" rack panel; module suitable for multichannel installations; and cabinet.—*Vidar Corp.*, 2107 *El Camino Real, Palo Alto, Calif.*

CIRCLE 159 ON READER-SERVICE CARD

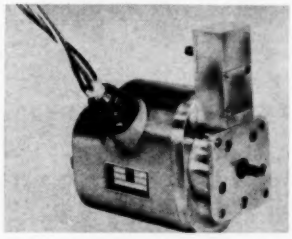
CHEMICAL LIQUID METER



New Chemical Liquid Meter, Model BNV, is made in ¾" size and is constructed of Type 316 s.s. The measuring piston, can be of any of a variety of materials as required. Available with threaded or flanged connections. —*Buffalo Meter Co., Inc., Buffalo, N. Y.*

CIRCLE 259 ON READER-SERVICE CARD

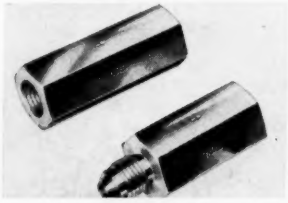
IMMERSIBLE ACTUATOR



New miniature motor-driven actuator for operating ball valve submerged in gasoline develops 100 in-lb starting torque with a running torque of 25 in-lb. Cast aluminum alloy case withstands 20 psi pressure without leaking. Actuator shaft rotates 90° ± 1½° with Geneva movement to ensure repeatability in valve positioning. Operates on 115 v, 400 cps.—*Globe Industries, Inc.*, 1784 *Stanley Ave., Dayton 4, Ohio.*

CIRCLE 260 ON READER-SERVICE CARD

CHECK VALVES



New Check Valves, Series 400, are constructed with an "O"-ring seal that eliminates leakage. Four styles with male and/or female pipe; or male and/or female tube connection are available. Made in stainless steel, brass, aluminum, and steel. Service is up to 5000 psig.—*Quality Control Corp.*, 7315 *Wilson Ave., Chicago* 31, *Ill.*

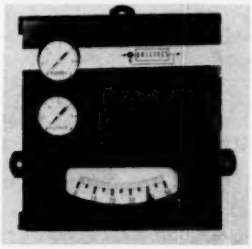
CIRCLE 261 ON READER-SERVICE CARD

PRESSURE TRANSDUCERS

New series of high-precision Pressure Transducers utilizes a free-edged circular diaphragm of Ni-Span-C in the sensor to increase system accuracy. Full scale ranges are from 1 to 100 psig and differential or absolute pressure measurements can be made. Temperature range is from −55 to 100°C; sensitivity is less than 0.01% of full scale pressures. Bulletin 36010 contains details.—*Rosemount Engrg. Co., 4900 W. 78 St., Minneapolis 24, Minn.*

CIRCLE 262 ON READER-SERVICE CARD

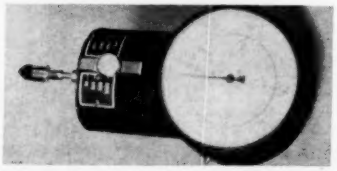
INDICATING CONTROLLER



New line of position-balance Indicating Controllers for pressure, temperature, flow, differential pressure, humidity, and differential liquid level, A/D (advance design) Model 624, features simple modular design for ease of servicing, and high stability for closer process control. Controllers are available with 1 to 400% proportional band, and reset control with 0.1 to 50 repeats/min. The frequency response curve is essentially flat to 400 cpm (proportional) and 325 cpm (proportional plus reset).—*Bristol Co., Waterbury, Conn.*

CIRCLE 263 ON READER-SERVICE CARD

HAND TACHOMETER



New Model HT-12 four-range Hand Tachometer, centrifugal type, has stop-button feature to retain readings on dial until released. Measures rpm as well as ft/min. Total Range: 90 to 12,000 rpm, divided into four separate ranges: 90-360 rpm; 300-1200 rpm; 900-3600 rpm; and 3000-12,000 rpm. Accuracy is ½ of 1%.—*Kernco Instruments, Inc., Box 1284, Church St. Station, New York 8, N. Y.*

CIRCLE 264 ON READER-SERVICE CARD

NEW! Meter Recorder Marking System with a Slip-In Cartridge!

Esterbrook's *customized* marking systems guarantee you complete satisfaction . . . for *any* type recorder . . . Circular . . . Strip . . . Miniature *or* Plotter!

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Give your customers the benefit of *ink cartridge convenience,* and a century of experience in the recording product you build. . . . Now—Esterbrook's Technical Products and Instrument Division will custom-design and build a new marking system for *your* product.

The result: no more breaking down . . . no more hand fixing! With Esterbrook's new *customized* meter recorder you'll conserve operating time . . . *and* you'll receive the free design time and engineering assistance of experts!

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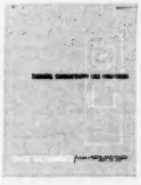
CIRCLE 119 ON READER-SERVICE CARD

INSTRUMENT DAVIS DIVISION

Gas Analysis Instrumentation

Combustible Gas Detector Systems. Continuous Plant & Work Area Control. **Bulletin 11-36**

Parts Per Million Analyzers — For measurement of toxic gases and vapors. **Bulletin 11-70**



Thermal Conductivity Gas Analyzers. Gas Purity and Plant Process Control. **Bulletin 11-17**

Continuous Oxygen Analyzers. Systems for analyzing and recording Oxygen content of process gases. **Bulletin 11-40**

CHROMA-MATIC Process Stream Analyzers. High speed Chromatography units for Plant Stream Monitoring and Process Control. **Bulletin CM 1-59**

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CIRCLE 120 ON READER-SERVICE CARD

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By the Thermal Conductivity Method —

- HOT WIRE FILAMENTS IN MATCHED PAIRS (Available from stock)
- ON-STREAM DETECTOR CELLS
- CHROMATOGRAPHY DETECTOR CELLS For ¼" Columns and Capillary Columns*
- TEMPERATURE REGULATED CELLS TO 300° C+
- PORTABLE ANALYZERS (Gas Masters)
- PANEL INSTRUMENTS — Indicate — Record — Control
- GAS BLENDER (Automatically mixes forming gas and other binaries)
- EXPLOSION-PROOF UNITS

By the Gas Density Method —

- DETECTOR CELLS*
  - — No Calibration Required
  - — Linear Across Broad Ranges
  - — Less than 1% Error
  - — Nitrogen Eluting Gas
  - — Non-destructive to Sample

*Indicates new product

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GAS ANALYSIS BY THERMAL CONDUCTIVITY SINCE 1935

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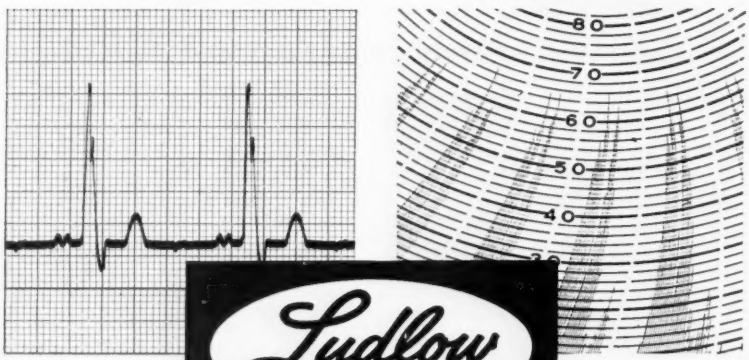

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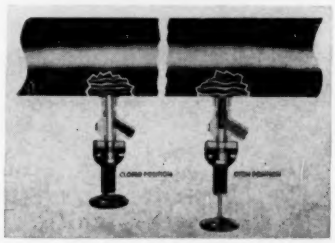
You get the full potential from your recording systems when you use custom-made chart papers by Ludlow. Precision engineering assures constant fidelity. Write for free samples and literature or tell us your requirements. Ludlow Papers, Ware, Massachusetts, Dept. 162.

CIRCLE 122 ON READER-SERVICE CARD

NEW INSTRUMENTS

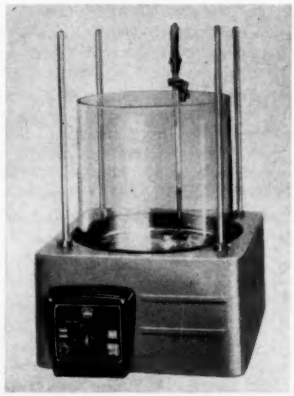
LINEAR ACCELEROMETER



New Linear Accelerometer, Series A65, whose size and light weight make it ideally suited for in-flight instrumentation applications, responds flat within ±5% from static to 830 cps. Embodying Statham's unbonded-strain-gage principle, with the resistive elements arranged in a complete Wheatstone bridge, it provides the accuracy, reliability and long service life characteristic of this gage. Model variations are available in a wide range from ±7.5g to ±150g. Requiring an excitation of 5v dc or ac, the new accelerometer has a nominal output of ±20 mv. Its combined nonlinearity and hysteresis is less than ±1% of full-scale output.—*Statham Instruments, Inc.*, 12401 *Olympic Blvd., Los Angeles* 64, *Calif.*

CIRCLE 265 ON READER-SERVICE CARD

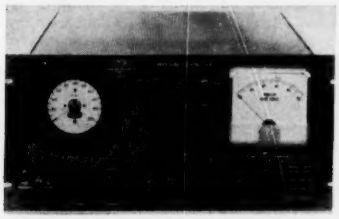
RADIANT HEAT BATH



New Radiant Heat "Hi-Accuracy" Bath provides 95% free working volume. Dual heating controls furnish balanced radiant heat by use of a special infrared lamp, without immersion heaters. Accuracy and uniformity are maintained to ± 0.002°C. Includes a large-capacity centrifugal pump which circulates more than 15 gpm, and a new magnetic-diffusion system. Two models are made: 12" dia x 12" deep, and 12" dia x 18" deep.—*Labline, Inc.*, 3070 *W. Grand Ave., Chicago* 22, *Ill.*

CIRCLE 266 ON READER-SERVICE CARD

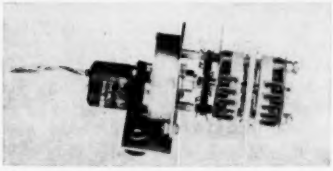
PRESSURE CONTROLLERS



New electronic Pressure Controllers are made in three models: (1) Model 56A consists of a transistorized servo amplifier and a d-c amplifier capable of driving electrohydraulic servo valves. (2) Model 57B consists of an oscillator, a meter-amplifier and meter and a set point control, a pre-amplifier, a rate and integration network, and a d-c power amplifier to drive the electrohydraulic valve which controls the control valve actuator; and (3) Model 501B consists of an a-c amplifier, and a 3-kc oscillator and power supply.—*Micro Gee Products, Inc., Box* 1005, 6319 *West Slauson Ave., Culver City, Calif.*

CIRCLE 267 ON READER-SERVICE CARD

GENEVA DRIVE MECHANISM



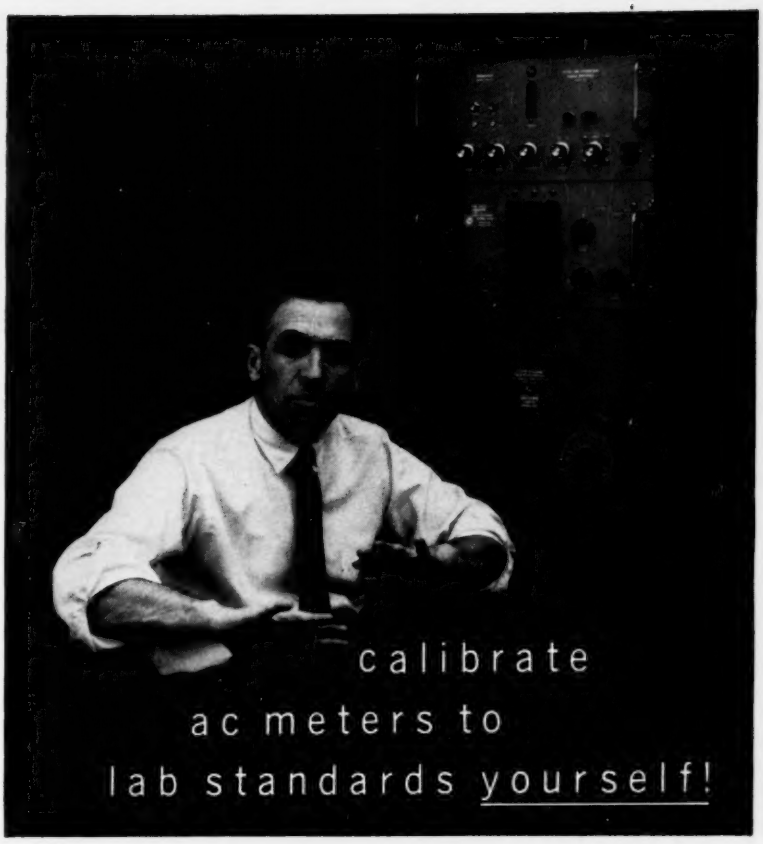
New Switch Drive Mechanism of the Geneva type operates remotely and reliably any rotary switch. With a maximum operating load of 50 in-oz and variable indexing, the Geneva-drive mechanism eliminates overthrow (accurate and positive positioning assured), has mechanically precise positioning (no detent action).—*Wilcox Electric Co., Inc., Fourteenth & Chestnut, Kansas City* 27, *Mo.*

CIRCLE 268 ON READER-SERVICE CARD

BEAM SWITCHING TUBE

New Trochotron Beam Switching Tube allows supply voltages to be utilized from 300 v for operation in conventional tube circuits, to below 28 v for transistor circuits. A Trochotron can replace as many as twenty transistors or tubes and numerous other circuit components. These tubes overcome many of the limitations encountered in the use of Dekatron and other counting circuits.—*Baird-Atomic, Inc.,* 33 *University Rd., Cambridge* 38, *Mass.*

CIRCLE 269 ON READER-SERVICE CARD



with this stable,

low-distortion ac power source

New from Krohn-Hite: this variable-frequency, 50 watt ac power source, with less than 0.01% amplitude stability and 0.1% harmonic distortion! The LDS-1500 offers a continuously-variable wide range of voltage and current — up to 1500 volts, and up to 12 amps, at *any* frequency from 20 cps to 20 kc.

Here is the long-desired combination of short-term stability and low distortion for calibration, by the comparison method, of all conventional indicating ac voltmeters and ammeters, and digital meters normally used for laboratory measurements.

Now you can calibrate your own meters at precisely the frequencies you require. Because of the push-buttons and vernier controls, frequency settings are positive, convenient, and resettable to better than 0.01%.

As a general-purpose variable frequency source of distortion-free, highly stable power, the LDS-1500 has many other applications. Quality-control testing for distortion or performance of components requiring a variety of power supply frequencies is simplified. The 50 watt power output is ample to supply test benches.

Send for full information on this unusual ac power source!

KH

KROHN-HITE CORPORATION

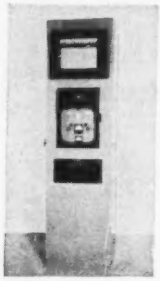
580 Massachusetts Avenue • Cambridge 39, Mass.

Pioneering in Quality Electronic Instruments

CIRCLE 123 ON READER-SERVICE CARD

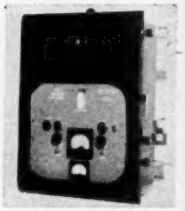
J-W

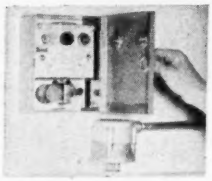
Systems for Continuous Checking for Explosive Gases



J-W Model RV Alarms sample and analyze air at 2 to 8 locations and relay information to main analyzer panel. Recording instruments and explosion-proof construction available on order.

J-W Model SM Alarm continuously checks one location where accessibility is a problem; alarms at a pre-set level.





J-W Model E Alarm detects explosive gases in a single area; control box mounts remote from sensing unit. Model EE also available with units encased in explosion-proof housing.

Do you have a problem with combustible gases that requires a special detection system design? Experienced J-W engineering is available to help you with meeting the situation. For complete data on services and standard and custom J-W equipment, please write:

JOHNSON-WILLIAMS, INC. Palo Alto 13, California

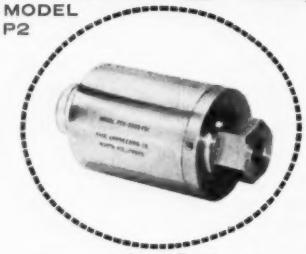
Leaders in Explosion Prevention Since 1927

Canadian customers please write: **SAFETY SUPPLY CO.** TORONTO, ONT. **FLECK BROS. LTD.** VANCOUVER, B. C.

CIRCLE 124 ON READER-SERVICE CARD

PACE

MODEL P2



magnetic reluctance

PRESSURE TRANSDUCER

Ranges: 200 to 10,000 psi — Gage or Absolute.

Pressure Media: Corrosive liquids, gases and solid suspensions.

Insensitive to Shock and Vibration.

PACE's Model P2 is designed for static and dynamic measurement in missile, aircraft, laboratory and ground test applications.

PACE *engineering company*
13035 Saticoy Street
North Hollywood, California
TRiangle 7-7139

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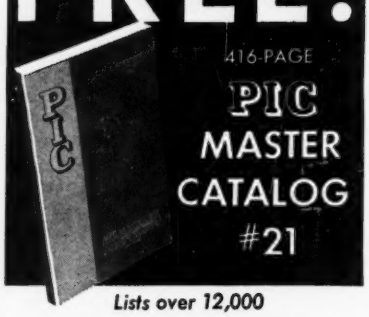
FREE!



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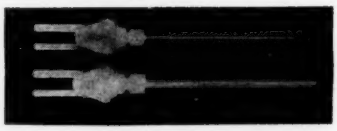
CIRCLE 126 ON READER-SERVICE CARD

NEW INSTRUMENTS

SWAGE-TYPE T/C's



New line of fast-response industrial Type A+ Thermocouples with swage design are shock- and vibration-resistant and have outstanding electrical insulation characteristics up to 2500°F. Withstanding pressures up to 40,000 psig, and made to ISA standards, they are available in a variety of materials, calibrations, and connections with corrosion-resistant outer sheath. Calibration options are standard Chromel-Alumel, Iron-Constantan, and Copper-Constantan.—*Atkins Technical Inc., 1276 West Third St., Cleveland 13, Ohio.*

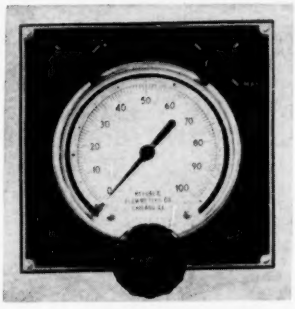
CIRCLE 270 ON READER-SERVICE CARD

WIDE-RANGE VACUUM GAGE

New wide-range Discharge Vacuum Gage and Controller that measures vacuum from 0.001 μ up to 20μ of Hg, gives direct readings of pressures, using a gage tube that operates on the cold-cathode discharge principle. Unit is instantly self starting at any pressure from 760 mm to 0.001 μ. A controller provides automatic on-off switching action for operations performed within or outside of the vacuum system.—*Central Scientific Co., 1700 Irving Park, Rd., Chicago 13, Ill.*

CIRCLE 271 ON READER-SERVICE CARD

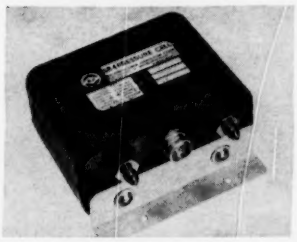
MANUAL CONTROL STATIONS



New line of pneumatic Control Stations for bumpless transfer between automatic and manual operation as well as for set point loading and manual loading operating with the Vector series instruments and controls have input and output ranges of 3-to-15 psig, with air consumption of less than 0.2-scfm. Accuracy is 1% of full scale.—*Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill.*

CIRCLE 272 ON READER-SERVICE CARD

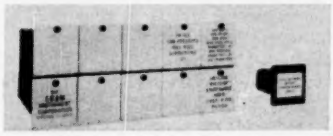
PRESSURE CELL



New low capacity, high-accuracy Pressure Transducer, Type MM, for measuring differential, absolute, or gage pressures uses bonded strain gages and bellows assembly. Resistance change is directly proportional to pressure. Features include high output (3 mv/v), 350 ohms input impedance, standardized performance, complete interchangeability, high accuracy and terminal linearity within ±0.1% of full scale. Cell capacities are ± 15, 30 and 60 psig.—*Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., 42 Fourth Ave., Waltham 54, Mass.*

CIRCLE 273 ON READER-SERVICE CARD

ANNUNCIATOR NAMEPLATE



New Magna-Plac Nameplate features 70% more engraving area by elimination of a metal frame around the white translucent acrylic cover. Overall dimensions are 3¾" x 3⅜", of which 3⅜" x 3⅛" is useable engraving area. Standard nameplates are 2¼" x 2¾" overall.—*Scam Instrument Co., 1811 W. Irving Park Rd., Chicago 13, Ill.*

CIRCLE 274 ON READER-SERVICE CARD

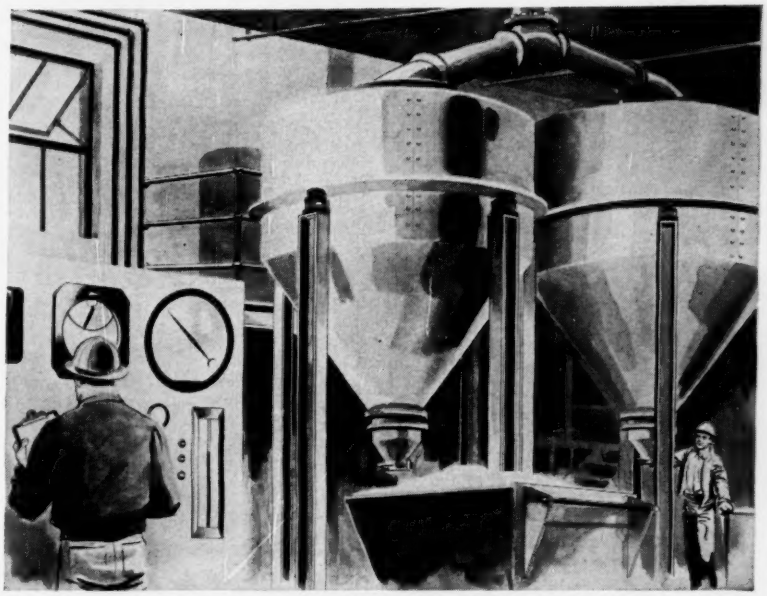
NITROGEN ANALYZER

New Automatic Nitrogen Analyzer, Model 29, which affords a fully-automated method of performing the micro-Dumas process of nitrogen determination within 15 min, features high accuracy, high speed, digital readout, etc. Bulletin B-258 contains details.—*Coleman Instruments, Inc., 42 Madison St., Maywood, Ill.*

CIRCLE 275 ON READER-SERVICE CARD

EMERY ENGINEERED WEIGHING SYSTEM

Provides Maximum Accuracy for Pulverized Vitamin C Installation



Explosion-Proof Equipment Provides Control For Hopper-Filling Mechanism

A pharmaceutical manufacturer wanted to weigh powdered ascorbic acid as part of its process in making Vitamin C tablets. The powder is gathered in hoppers which weigh 3500 pounds and handle a maximum net load of 8750 pounds.

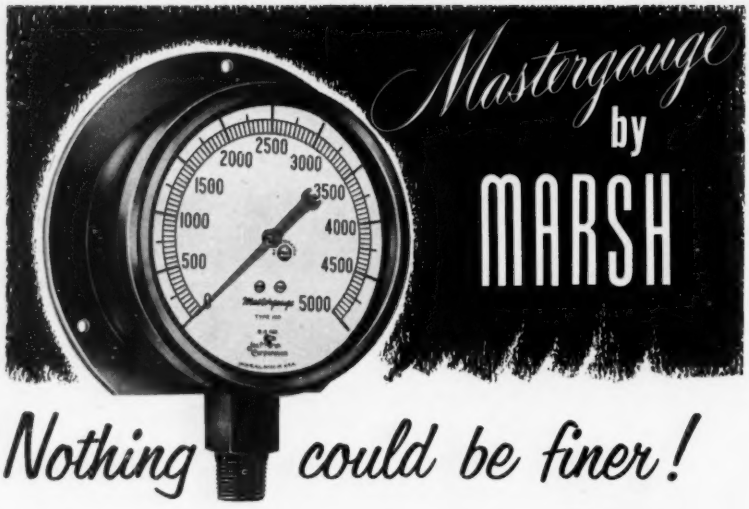
The conditions demanded that the equipment be explosion-proof and that the weighing signal be used to actuate automatically a diverting gate in the filling system which would switch the in-flow from one hopper to another.

An Emery Engineered Weighing System, based on the use of 4 Model EC-30 load cells and a hydraulic totalizer and using a 16" Emery Precision Indicator together with a Foxboro controller, handled the hopper-weighing job with an accuracy of ¼% of full range. Customer satisfaction is guaranteed.

If you have a tank, bin or hopper weighing problem which involves a control function, write today. Our literature is graphic, descriptive and easy to use in figuring a system for your installation. The A. H. Emery Company, Pine Street, New Canaan, Conn.

EMERY
weighing systems

CIRCLE 127 ON READER-SERVICE CARD



Nothing could be finer!

Mastergauge alone brings you "Conoweld" leak-proof, one-piece tubing and socket; sturdier Marshalloy case; precision mastergauge movement; stainless tube and socket when required.

Mastergauge is standard bearer for the broad line of Marsh Gauges for every service.

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Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta
Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

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MACHINE-DIVIDED SCALES

Made with latest SIP Swiss Automatic Dividing Machines

LINEAR
Accuracy to ±5 microns (0.0002")

CIRCULAR
Accuracy to ±5 seconds

Any scale pattern—Any line width—Any material

FINE MACHINE ENGRAVING
Scales, Dials, Drums, Rods, Panels

ACCURATELY ETCHED RETICLES
Made in any specified pattern and dimensions

PRECISION MACHINE-RULED MASTERS
For printed circuits, i.e., commutators, switches, and general circuitry

L. C. RENICK CO.
308 So. Salsipuedes St., Santa Barbara, Calif.
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IN-LINE DIGITAL DISPLAYS
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Series 10000
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OUTSTANDING FEATURES
- All digits displayed on front viewing screen
- All digits uniform in size and intensity
- High-contrast viewing screen
- Digit style of your choice
- Colored digits of your choice
- Individual units may be group assembled for panel mounting

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1 9/16" wide
2 3/8" high
5 5/8" long
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Series 80000
3 1/4" wide
5 1/4" high
11 15/16" long
$33.00 each

Series 120000
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INDUSTRIAL ELECTRONIC ENGINEERS, Inc.
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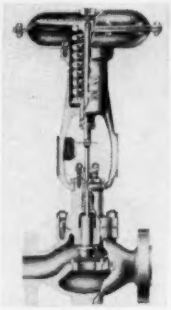
CIRCLE 130 ON READER-SERVICE CARD

NEW INSTRUMENTS

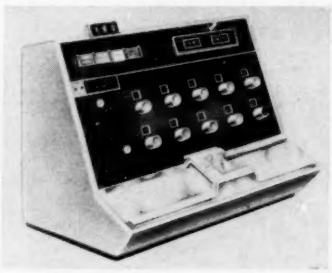
CONTROL VALVES



New 20000 Series of Single Seated Control Valves features high capacity, ability to handle high pressures and pressure drops, and a wide selection of reduced capacity trim. Top-guided, their unrestricted seat-ring area with body and plug contours provide greater capacity than most top-and-bottom-guided double seated valves of comparable sizes. Available in sizes from ¾" to 10" with ratings in iron of class 125 or 250 lb ASA, and in steel from 150 to 2500 lb ASA. Screwed, flanged, or welded ends are furnished.—*Mason-Neilan, 63 Nahatan St., Norwood, Mass.*

CIRCLE 276 ON READER-SERVICE CARD

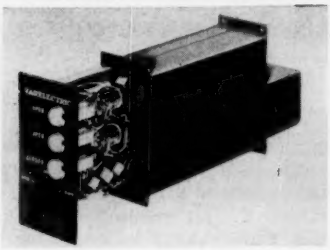
DATA COLLECTOR



New 180 Data Collector automatically assembles into a punched paper tape variable data (such as job-lot number and amount produced), identification data from pre-punched IBM cards (such as employee number and item number), fixed data (such as department number and Data Collector number), and time from an internal clock (to the nearest 0.01 hr). Variable data are inserted from 10 manually-operated dials. The identification data are selectively read from IBM cards by a unique card reader employing a pneumatic principle. 8-page bulletin gives details.—*Control Data Corp., 501 Park Ave., Minneapolis 15, Minn.*

CIRCLE 277 ON READER-SERVICE CARD

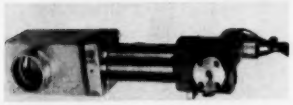
VALVE CONTROL SYSTEM



New two-wire Supervisory Control System Varelectric, provides direct, instantaneous control of pump motors, valve operators, and similar equipment using only one wire between each control and field unit, plus one conductor common to many units. The wiring is not critical and the signal is a direct, continuous current. No power is required at the field end. —*Vapor Recovery Systems Co., 2820 N. Alameda St., Compton, Calif.*

CIRCLE 278 ON READER-SERVICE CARD

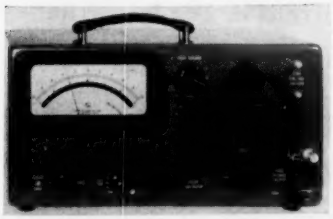
VACUUM VALVES



New complete line of compact pneumatically-operated vacuum valves, Type "PV", of bellows-sealed construction are available in ⅝", 1" and 1½" port size. Each valve is individually tested on a Veeco mass spectrometer leak detector assuring no leak at a sensitivity of 1 x 10^{-10} std cc/sec. Available for either right angle, or in-line application with pipe thread or solder connections. Solenoid pilot valve automatically keeps valve in preselected open or close position in case of an electrical power failure.— *Veeco Vacuum Corp., 86-P Denton Ave., New Hyde Park, L. I., N. Y.*

CIRCLE 279 ON READER-SERVICE CARD

INCREMENTAL VOLTMETER



New battery-powered Incremental Voltmeter, Model 130, for precision measurement of d-c voltages, incorporates an offset voltage source variable from 0 to 509 v and accurate to 0.1%. Utilizing this source and the instrument's high-input resistance-increment-reading meter, dc voltages over the range 10 mv through 500 v can be read with an error or indication not exceeding 0.2%.—*Belleville-Hexem Corp., 638 University Ave., Los Gatos, Calif.*

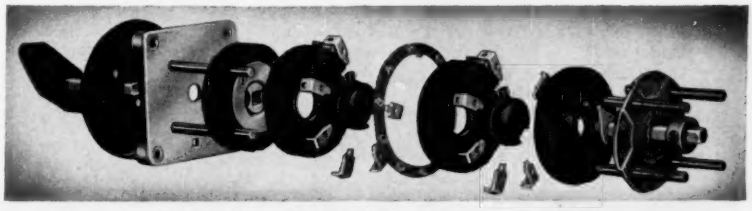
CIRCLE 280 ON READER-SERVICE CARD

DESIGN NOTES on
Control by Rotary Switches

(No. 1 of a series)

The multi-pole, multi-circuit, rotary switch is one of the most versatile devices for control of electric circuits yet it is not as widely used as it should be, because many designers are not familiar with its construction and application.

In these Design Notes, the operating principle and the structural features of rotary switches will be discussed in relation to a wide variety of controls — some simple, some complex, some light-duty, some heavy-duty, and some that defy classification.



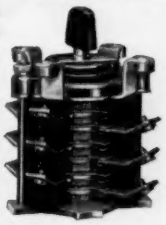
Exploded view of ESCO Type JR – a typical rotary switch.

The type of switch we are talking about does not fit into any clearly defined category. It is called a *rotary switch* because its moving parts rotate on a shaft so that the switch can be operated by turning a knob, handle, or hand-wheel — either manually or by a motor, solenoid, or other form of power drive. Altho the term *rotary switch* is sometimes loosely used to mean any switch that can be operated by turning a shaft (as in the case of a switch having cams that open and close contact circuits), there are important differences that put the true rotary switch in a class by itself for many applications.

Basic Structure of Rotary Switch

The first characteristic to be considered is the physical arrangement of the contacts. In the rotary switch, stationary contacts are distributed radially on an insulating base, generally called a *deck*, or a *section*. Sometimes they are riveted or otherwise secured to the deck but more often they are set in molded recesses.

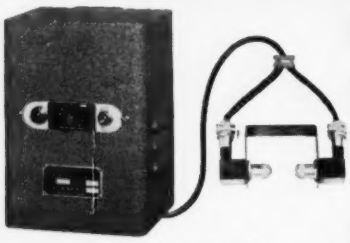
The movable contacts, which are carried on an insulating member keyed to the switch shaft, are free to move slightly so as to align themselves with the stationary contacts. Since the shaft is generally made of metal, insulation adequate to prevent flashover is provided between the movable contacts and the shaft. In some designs, the movable contacts are connected to the external circuit through a slip ring; such switches are generally called tap, or selector switches. For more complex circuit controls, the movable contacts may be used to interconnect two or more stationary terminals.



ESCO Bulletin No. 8A, containing useful information on the construction and application of rotary switches, as well as examples of ESCO switches that utilize the design principles discussed in these advertisements, will be sent you on request.

ESCO of WEYMOUTH
ELECTRO SWITCH CORP.
Weymouth (Boston 88), Massachusetts

CIRCLE 131 ON READER-SERVICE CARD



POST ELECTRONIC PRODUCTS

Model K-1A — When the light beam is not interrupted — output relay is energized.
Model K-1B — When the light beam is interrrupted — output relay is energized.

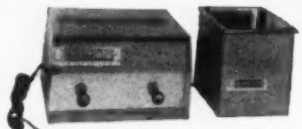
Model K-2 — Photoelectric timer with adjustable (.05-10 sec.) output relay closure.

Model K-3 — Photoelectric stop-motion and jam detector:
K-3R — When light beam is interrupted for the present time delay-output relay is energized.
K-3F — When light beam interruptions cease for a preset time delay-output relay is energized.

Decitron

POST ELECTRONIC PRODUCTS
Division of Reid Brothers Company, Inc.
12 LOTHROP ST. / BEVERLY, MASS.

CIRCLE 132 ON READER-SERVICE CARD



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Choice of 7 beautiful decorator colors to harmonize with your office or laboratory decor: Ivory, Wheat yellow, Turquoise, Desert sand, Pale green, Soft gray and Coral pink. Please specify color when ordering.

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CIRCLE 133 ON READER-SERVICE CARD

HARDNESS TESTING

SCLEROSCOPE FOR TESTING THE HARDNESS OF METALS. PIONEER AMERICAN HARDNESS STANDARD. OVER 40,000 IN USE. (ASTM A427)

DUROMETER FOR TESTING THE HARDNESS OF RUBBER & RUBBER-LIKE MATERIALS (ASTM D676) (ASTM D1484) (ASTM D1706)

SHORE INSTRUMENT & MFG. CO., INC.
90-35 VAN WYCK EXP.
JAMAICA 35, N. Y.

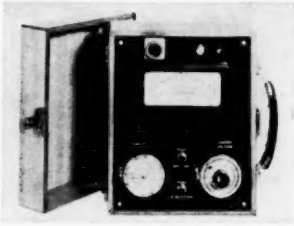
CIRCLE 134 ON READER-SERVICE CARD

MIDGET AIR CYLINDERS

New series of double-acting Midget Air Cylinders has 1" bores and is suitable for air pressures up to 125 psig. There are six models in the series, each offering a different stroke, namely 1", 2", 3", 6", 9", and 12". Overall length of the smallest cylinder, which has a 1" stroke, is 4-19/32". The largest cylinders, with 12" stroke, is 15-19/32" long.—*A. Schrader's Son, Div. of Scovill Mfg. Co., Inc.*, 470 *Vanderbilt Ave., Brooklyn* 38, *N. Y.*

CIRCLE 281 ON READER-SERVICE CARD

DEVIATION VOLTMETER



New Deviation Voltmeter reading directly in % deviation as well as in volts has two scales: −100 to +100 v and −5% to +5% deviation. Voltage applied to the meter is indicated on the −100 to +100 volt scale with a ±2% accuracy. Switch is pushed and meter reads directly in % deviation of applied voltage from nominal voltage with accuracy of ±¼% to 1/10%. Made as rack-mounting, or as portable model.—*Voltron Products Inc.*, 1020 *So. Arroyo Parkway, Pasadena, Calif.*

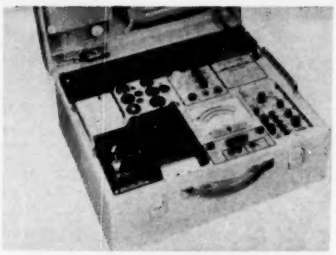
CIRCLE 282 ON READER-SERVICE CARD

PHASE SHIFT CONTROL

New Silicontrol provides failsafe full range phase shift control for silicon controlled rectifiers by applying 60-cycle steep pulses of constant amplitude to rectifier gates and varying their phase angle over a full 180° to control the rectifier output from zero to maximum. Pulse rise time is only a few μsec.—*VecTrol Engineering, Inc., Box* 1089, *Stamford, Conn.*

CIRCLE 283 ON READER-SERVICE CARD

CARDMATIC TUBE TESTER



New Cardmatic Automatic Tube Tester, Model 1234, has a greater Gm range, and features an easily-accessible calibration compartment located in the top panel of the tester.—*Hickok Electrical Instrument Co.*, 10514 *Dupont Ave., Cleveland 8, Ohio.*

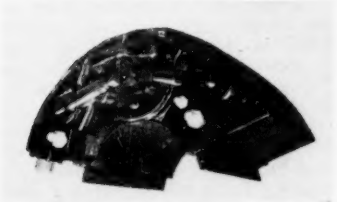
CIRCLE 284 ON READER-SERVICE CARD

ELECTRONIC COUNTERS

Two new all-purpose Electronic Counters, Models 523CR and 523DR, directly measure frequencies from 10 cps to 1.2 Mc, time intervals from 1 μsec to 10^6 sec and periods from 0.00001 cps to 100 kc. Stability is 2/1,000,000 per week. Model 523CR has an in-line readout, Model 523DR has readout by 6 columnar neon indicators instead of the in-line digital display. Accuracy is ± 1 count $\pm$ crystal stability.—*Hewlett-Packard*, 275 *Page Mill Rd., Palo Alto, Calif.*

CIRCLE 285 ON READER-SERVICE CARD

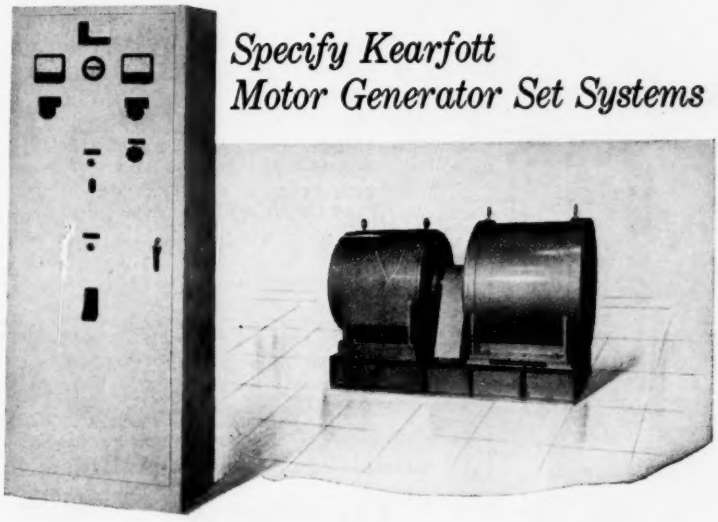
SILVER-ZINC BATTERY



New Model P13A "shaped" Silver-zinc Battery, designed as a main power supply for missile electronic equipment and instruments, etc., has 40 dry charged cells which are automatically activated by an electrically-ignited, solid-propellant gas generator. Output is 11 kw. Current rating is from 180 amp to 1000 plus, with a maximum of 3700 amp. Capacity of the 56-v battery is 7.5 amp-hrs with a discharge (shorting) time of 2.5 min.—*Cook Batteries, a div. of Telecomputing Corp.*, 3850 *Olive St., Denver, Colo.*

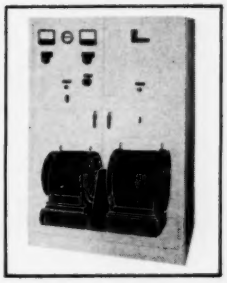
CIRCLE 286 ON READER-SERVICE CARD

FOR PRECISE 400-CYCLE POWER



Specify Kearfott Motor Generator Set Systems

Kearfott 60-to-400 cycle motor generator frequency converters are in active use wherever precise 400-cycle power must be supplied . . . including laboratories and in such other representative applications as production testing, high speed tool operation and ground support. These generator systems, which consist of a 60 cycle synchronous motor and a 400 cycle generator, can be supplied with controls and generator as an integral, compact unit—or with controls and generator separately located.



PERFORMANCE SPECIFICATIONS

Frequency: 400 cycles under any rated load condition with 60 cycle input.

Voltage Regulation: Within $\pm 1\%$ of rated voltage when (1) load varies between no-load and 125% of rated load, and/or (2) load power factor varies between 0.8 lagging and unity, and/or (3) equipment temperature varies after approximately 10 minutes' operation.

Voltage Recovery: When rated load is suddenly applied or removed, voltage will return to and remain within regulating band within 0.25 seconds.

Voltage Adjustment: Continuously adjustable to $\pm 10\%$ of rated value.

Deviation Factor: Maximum 4% between no load and full load.

Overload: Equipment delivers 125% of rated load for 2 hours.

Amplitude Modulation: Maximum 1% of peak-to-peak voltage at any load between no load and full load, at any power factor between 0.8 lagging and unity.

Frequency Modulation: Maximum 0.5% at any load from no load to 125% of rated load.

GP

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

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BELLOWS SEAL VALVES

For Space-Missile and Process Control

- ►**SEMI-STEEL** TOP WORKS
- ► TOP WORKS PROPERLY SIZED FOR VALVE BODY
- ► TOTALLY ENCLOSED SPRING
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- ► REMOVABLE PLUG WITHOUT REPLACEMENT OF BELLOWS

High quality materials, engineering know-how and superior design assures long maintenance-free operation under many process conditions.

If you are now using valves with bulky top works and are experiencing corrosion and operational problems, check and compare UNIFLOW VALVES TODAY.

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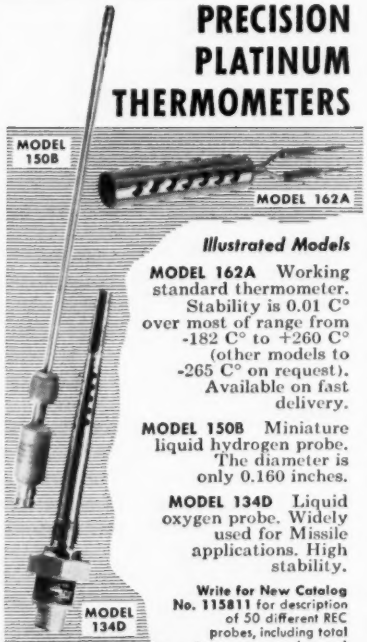
PRECISION PLATINUM THERMOMETERS



Illustrated Models

MODEL 162A Working standard thermometer. Stability is 0.01 C° over most of range from -182 C° to +260 C° (other models to -265 C° on request). Available on fast delivery.

MODEL 150B Miniature liquid hydrogen probe. The diameter is only 0.160 inches.

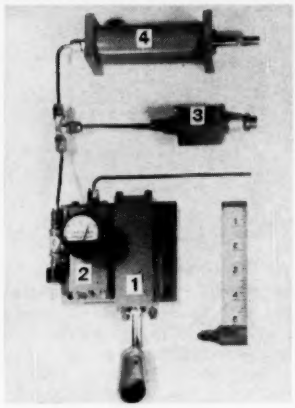
MODEL 134D Liquid oxygen probe. Widely used for Missile applications. High stability.

Write for New Catalog No. 115811 for description of 50 different REC probes, including total temperature probes and surface probes.

ROSEMOUNT ENGINEERING COMPANY
4902 West 78th St.
Minneapolis 24, Minn.

CIRCLE 138 ON READER-SERVICE CARD

SAFETY CONTROL SYSTEM



New non-electric Calcon Safety Control System is sensitive to a wide range of temperatures and pressures, or both in combination. Unit which operates through a small captive charge of compressed air and provides immediate, positive-action response, can sense pressures up to 200 psig. It has its own source of pneumatic power and is not dependent on outside power.—*California Controls Co., Dept.* 103, 1525 *Powell St., Oakland* 8, *Calif.*

CIRCLE 287 ON READER-SERVICE CARD

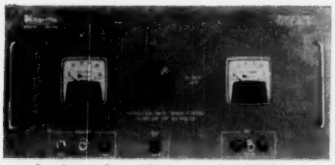
MASS SPECTROMETER

New laboratory Analytical Mass Spectrometer, Model 21-130, has mass ranges of m/e 2 to 4, 5 to 11, and 12 to 230, continuous, with unit resolution at m/e 200. Changing from one mass range to another is accomplished by merely flipping a switch. Cabinets are constructed of Formica-and-honeycomb panels which leave the internal mechanisms exposed for servicing. Other features include: A permanent magnet which greatly reduces weight and size; improved sensitivity resulting from an improved d-c ion current amplifier of the unity gain type; a direct-printout oscillograph in the recording system, etc.—*Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 288 ON READER-SERVICE CARD

REGULATED POWER SUPPLY

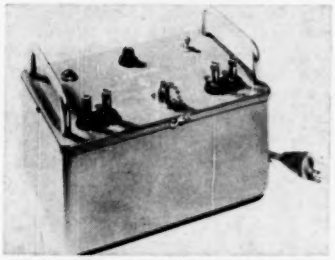
New transistorized Voltage Regulated D-C Power Supplies, Model SM-36-15, which extends the power capability of semi-conductor circuitry to levels formerly handled only by vacuum tube and magnetic designs, features output of 0-36 vdc, 0-15 amp.



Regulation for line or load is 0.1% or 3 mv; stability of 0.1%or 6 mv for 8 hrs; ripple of less than 1 mv rms; recovery time of 50 μsec, and output impedance of 0.005 ohms from dc to 1 kc, 0.05 ohms from 1 kc to 100 kc. Bulletin gives details.—*Kepco Inc., 131-38 Sanford Ave., Flushing 55, N. Y.*

CIRCLE 289 ON READER-SERVICE CARD

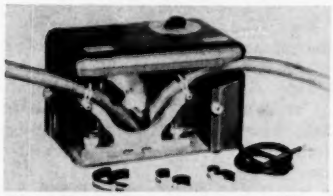
D-C AMPLIFIER



New M-10 Series Multipurpose-Chopper Stabilized D-C Amplifier has a current output proportional to a millivolt input. Model M-10A provides 0-5 mv input Model M10 0-10 mv, with 5 meg ohms input impedance. Output of both instruments is 0-1 ma for use with 0-1 ma meter movement recorders and meters so that signals from strain gages, remote thermocouples and other transducers in the frequency range of 0-2 cps may be measured.—*Houston Instrument Corp., Box 22234, Houston 27, Tex.*

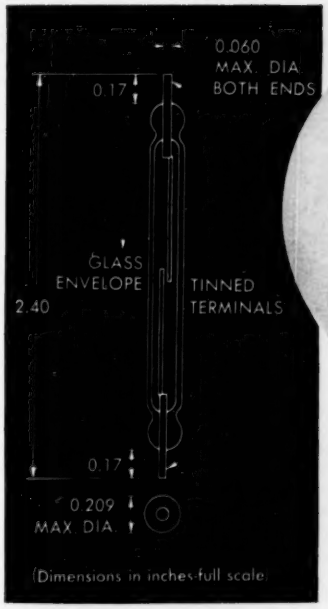
CIRCLE 290 ON READER-SERVICE CARD

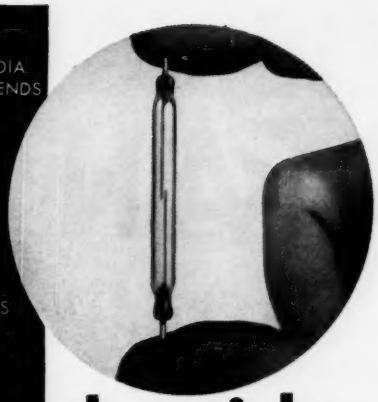
FLOW INDUCTION PUMP



New H. R. Flow Inducer utilizes a flexible hose on a multi-curved track to move liquids, slurries, emulsions, gases, creams, dried powder, etc. None of the materials ever touch any metal parts, passing entirely through the hose portion. Flow is variable from a few cc/min to nearly 500 gph. Characteristics include steplessly-variable motor up to 200 rpm, self-priming, can be used to generate and hold considerable vacuum, acts as oil-free compressor.—*Schuco Scientific, a div. of Schueler & Co., 75 Cliff St., New York 38, N. Y.*

CIRCLE 291 ON READER-SERVICE CARD





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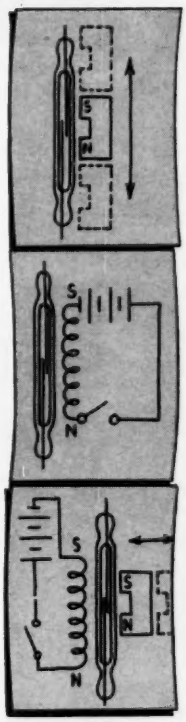
The magnetically actuated reeds in this tiny Revere GLASWITCH make contact in just 1 millisecond . . . at rates up to 400 cycles per second. Hermetically sealed in an inert, dry atmosphere, with lightning fast snap action, both shelf and contact life are extremely long. Smaller than a cigarette, the GLASWITCH can be located anywhere . . . in any position . . . even in explosive atmospheres . . . individually or in multiples for multi-contact use.

Whenever you need faster, more positive response . . . where extreme sensitivity is a must . . . where light weight is important . . . investigate the Revere GLASWITCH. Write today for complete specifications.



CHARACTERISTICS:

Type—Single pole single throw—normally open—snap action
Enclosure—Hermetically sealed glass tube containing inert dry atmosphere
Operating Time—1 millisecond
Operating Rate—Up to 400 cycles per second
Contact Surfaces—Electroplated Rhodium
Contact Resistance (measured terminal-to-terminal)
Closed Circuit—0.050 ohms maximum
Open Circuit—500,000 megohms minimum
Contact Ratings
DC—Up to 1 ampere
AC—Up to 25 watts depending on application
Reliability and Life
No Load—Billions of operations
Rated Loads—No failures to open or close in first 100,000 cycles
Ambient Temperature Range: —320°F to +300°F

METHODS OF ACTUATION:

A moving permanent magnet or controlled external electromagnetic field are all you need . . . and the sky's the limit on imagination!

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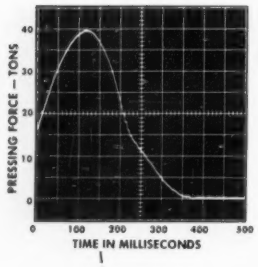
CIRCLE 139 ON READER-SERVICE CARD

USING STRAIN GAGES?



Information from strain gages and many resistive, capacitive, and inductive transducers can be displayed on the face of a cathode-ray tube . . . with the Type Q Plug-In Unit and any Tektronix Plug-In Oscilloscope.

You get a detailed picture of this information plotted against time, from which accurate measurements can be made with ease. The illustration, a plot of a press stroke, is an example of a quality-control application.

It's quite likely that your lab is already equipped with one or more Tektronix Plug-In Oscilloscopes. If so, the only additional expenditure will be the price of a Tektronix Type Q Plug-In Unit—$300 f.o.b. factory.

The Type Q Unit plugs directly into these oscilloscopes: Tektronix Types 531, 531A, 532, 533, 535, 535A, 536 (for X-Y plots), 541, 541A, 543, 545, 545A, 551 and 555 (dual beam), and all their rack-mounting versions. It can also be used in the Type 81 Plug-In Adapter with both the Type 581 and Type 585, and in the Tektronix 127 Preamplifier Power Supply with any standard laboratory oscilloscope and many other readout devices.

Maximum sensitivity of the Type Q is 10 microstrain/division when used with a single strain gage with a gage factor of about 2. Frequency range is dc to 6 kc (3 db down), with excellent transient response.

For complete information, or assistance with strain-gage and other transducer readout problems, please call your Tektronix Field Engineer.

Tektronix, Inc.

P. O. Box 500 • Beaverton, Oregon
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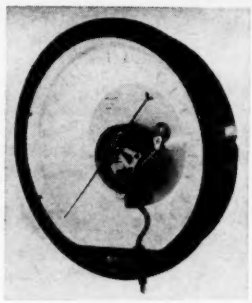
CIRCLE 140 ON READER-SERVICE CARD

ULTRA-HI PRESS TEST GAGE



New Test Gage for service in ranges up to 100,000 psig features (1) accuracy of 0.1% of full scale reading throughout the entire 270° dial; (2) hysteresis of not more than 0.1% of full scale reading from top pressure; (3) thermal stability through ambient temperature variations up to 100°F (where specified); and (4) certification of test results.—*Heise Bourdon Tube Co., Inc., Brook Rd., Newtown, Conn.*

CIRCLE 292 ON READER-SERVICE CARD

6-FT-STEM THERMOMETER

New Giant-Stem stainless-steel Thermometer withstands pressures up to 3476 psig and can be used for both liquids and gases. Hand calibrated for accuracies within 1% of the full scale reading. Available in ranges from 0-200°F to 200-1000°F. Dial sizes: 5", $1\frac{5}{32}$", $1\frac{1}{16}$", $2\frac{5}{16}$" and 3".—*W. C. Dillon & Co., Inc., 14620 Keswick St., Van Nuys, Calif.*

CIRCLE 293 ON READER-SERVICE CARD

ELECTROPNEUMATIC TRANSDUCER

New Electropneumatic Transducer, Type P2R Power Relay, that permits a pneumatic valve actuator to be used with an electronic control system, contains a 30-w heater in the pneumatic section that prevents moisture in the air from freezing the mechanism. A null-balance unit that contains no vacuum tubes, journal bear-

ings, or other friction surfaces, it is designed to work with a Swartwout Autronic primary-element transmitter and controller-recorder. Electrical input range is 1 to 5 mamp; air output is 3 to 15 psi.—*Swartwout Div. of the Crane Co., Hooksett, N. H.*

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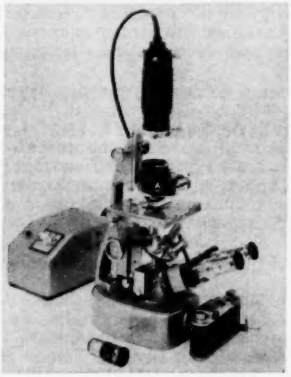
INVERTED MICROSCOPES



New line of Inverted Biological Microscopes, either monocular or binocular, gives magnifications up to 2000X. They feature built-in illumination and a wide choice of accessories, including a long working distance 40X objective and a choice of cameras. 8-page bulletin contains details.—*Unitron, Instrument Div. of United Scientific Co., 204-6 Milk St., Boston 9, Mass.*

CIRCLE 295 ON READER-SERVICE CARD

HEATED BOILER GAGES

New electrically-heated Boiler Gages employ a cartridge heater with a ½"-dia s.-s.-sheathed manganese-nickel wire. Made as external-tube models, either Reflex or Transparent type, and equipped with electrically-heated jacketed valves.—*Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.*

CIRCLE 296 ON READER-SERVICE CARD

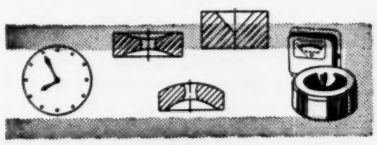
PRECISION

defined by the dictionary

. . . . "the quality or state of being precise; accuracy; mechanical exactness."

defined by an instrument maker . . .

Swiss American



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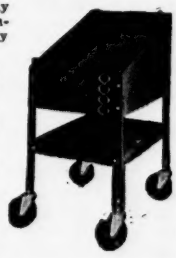
- ★ 3 power outlets; 1 input
- ★ Storage area for pre-amplifiers
- ★ Storage shelf for tools, cord, etc.



Accommodates any standard scope by easy bracket relocations. From 6" to 12¾" wide; from 16½" to 22½" long.

Shipped knocked down (45 lbs.), assembled in minutes. Special modifications to suit your requirements. Quantity prices on request.

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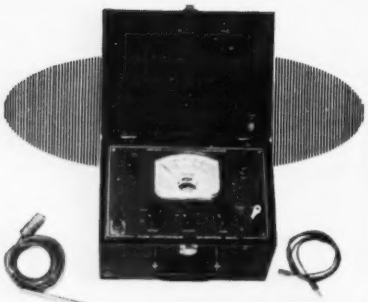

MODEL 54A1 **HOT WIRE ANEMOMETER**

for repeatable, reliable, accurate direct readings of air or gas velocity.

- Completely transistorized
- Rapid response — DC to 1 kc.
- Rechargeable batteries
- Feedback amplifier
- Portable
- Handsome Formica case
- Recorder output

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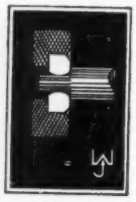
bearings and orifices
in sizes under ¼" O.D.



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ICS NEW LITERATURE

CONTROL SYSTEMS

MINIATURE ELECTRIC EYES. Bulletin #590 describes novel applications of miniature electric eyes for inspecting, sorting, counting, web control, registration level control, and all phases of packaging.—Photomation, Inc., 96 South Washington Ave., Bergenfield, N. J.

CIRCLE 297 ON READER-SERVICE CARD

PULSE WIDTH SELECTION SYSTEM. 4-page brochure contains complete technical specifications on the various modules that make up the complete pulse width selection system.—Hammarlund Mfg. Co., Inc., 460 West 34th St., New York 1, N. Y.

CIRCLE 298 ON READER-SERVICE CARD

VALVES

PLUG VALVES. 8-page Bulletin 110 describes Eccentric Valves listing features, materials, pressure ratings, dimensions, and accessories.—DeZurik Corp., Sartell, Minn.

CIRCLE 299 ON READER-SERVICE CARD

DIAPHRAGM-DISC VALVE. 2-page Bulletin 802 D illustrates and describes features of manually- and automatically-operated "D-D" valves.—W. S. Rockwell Co., 200 Eliot St., Fairfield, Conn.

CIRCLE 300 ON READER-SERVICE CARD

3-WAY VALVES. 12-page Bulletin 91023 describes line of Full Capacity Series, three-way valves for air, oil, water, gas, chemical or vacuum service.—Airmatic Valve, Inc., 7313 Associate Ave., Cleveland 9, Ohio.

CIRCLE 301 ON READER-SERVICE CARD

TEMPERATURE

THERMOCOUPLE ASSEMBLIES. Catalog G100-1 describes over 100 complete thermocouple assemblies in detail, including: new lower prices, specifications, photos, dimensions, and ordering information.—Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Aves., Phila. 44, Pa.

CIRCLE 302 ON READER-SERVICE CARD

TEMPERATURE CONTROLS. 12-page Bulletin 108 explains operation, circuitry and safety features of the three basic types of thermocouple-actuated Simplytrols.—Assembly Products, Inc., Chesterland, Ohio.

CIRCLE 303 ON READER-SERVICE CARD

TEMPERATURE POTENTIOMETERS. 2-page Preliminary Data Sheet ND42-33(1A) describes Type 8692 single-range and Type 8693 double-range portable temperature potentiometers.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

CIRCLE 304 ON READER-SERVICE CARD

FLOW, LEVEL

DALL FLOW TUBE. 4-page Bulletin Ref. No. 0115.20-3 contains drawings of 10 different styles of the Weldment-Type Dall Flow Tube together with engineering and ordering data.—B-I-F Industries, Inc., Box 1342, Providence 1, R. I.

CIRCLE 305 ON READER-SERVICE CARD

EXPLOSION-PROOF ILLUMINATORS. 2-page Data Sheet 375 covers features and sizes of Explosion-Proof Illuminators for liquid level gages.—Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

CIRCLE 306 ON READER-SERVICE CARD

PRESSURE, WEIGHT

PRESSURE RECORDERS. 8-page Catalog 800 illustrates and describes temperature and pressure recorders.—U. S. Gauge Div., of American Machine and Metals, Inc., Sellersville, Penna.

CIRCLE 307 ON READER-SERVICE CARD

CONVEYOR-SCALE SYSTEMS. 4-page Bulletin 60 describes the use of conveyor-scale systems for flow-rate control and total thru-put measurement of bulk materials.—Weighing & Control Components, Inc., 778 E. County Line Rd., Hatboro 10, Penna.

CIRCLE 308 ON READER-SERVICE CARD

PRINTWEIGH SCALES. 4-page Form 2023 describes Printweigh Scales giving automatically printed weight data.—Toledo Scale, Div., of Toledo Scale Corp., Toledo 12, Ohio.

CIRCLE 309 ON READER-SERVICE CARD

SPEED, TIME COUNT

ELECTRIC COUNTERS. 4-page General Bulletin describes all Sodeco electric impulse counting devices.—Landis & Gyr, Inc., 45 West 45th St., New York 36, N. Y.

CIRCLE 310 ON READER-SERVICE CARD

STOPWATCHES. 16-page catalog describes 66 improved stopwatch styles with accessories.—Heuer Timer Corp., 441 Lexington Ave., New York 17, N. Y.

CIRCLE 311 ON READER-SERVICE CARD

SPEED RECORDERS. 8-page Bulletin 260, describes and illustrates up-to-date applications of speed recording systems and relays.—Esterline-Angus Co., Dept. 26, Box 596, Indianapolis 6, Ind.

CIRCLE 312 ON READER-SERVICE CARD

SPEED DETECTION. 2-page Bulletin 264 describes three types of housed speed detecting governors as well as smaller components.—Torq Engineered Products, Inc., 32 W. Monroe St., Bedford, Ohio.

CIRCLE 313 ON READER-SERVICE CARD

DATA HANDLING

DATA PROCESSING SYSTEM. 6-page Folder DSA-31 and 3 application bulletins describe the Honeywell 400 magnetic-type processing system.—Minneapolis-Honeywell, DATAmatic Div., Wellesley Hills 81, Mass.

CIRCLE 314 ON READER-SERVICE CARD

SOLID-STATE COMPUTER. 25-page Bulletin T-20 illustrates and describes the G-20 System for high-speed scientific and business data processing.—Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.

CIRCLE 315 ON READER-SERVICE CARD

TAPE TRANSPORT. 4-page Bulletin DS 3170A describes Series 3170 magnetic-tape transports.—Minneapolis-Honeywell Regulator Co., Industrial Systems Div., 10721 Hanna St., Beltsville, Md.

CIRCLE 316 ON READER-SERVICE CARD

GRAPHIC REPRESENTATION LAB. 4-page spec sheet reviews applications of the Alden 5" Graphic Representation Lab 305 GPL for sonar, radar, spectrum analysis, and continuous temperature profiles.—Alden Electronic & Impulse Recording Equipment Co., Inc., Box 125, Westboro, Mass.

CIRCLE 317 ON READER-SERVICE CARD

MONITORING SYSTEMS. 8-page illustated brochure Form 3105-9 describes remote-area monitoring systems.—Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 318 ON READER-SERVICE CARD

COMPUTER FORMAT CONVERTER. 2-page brochure describes Model 2A-25159 which provides sampling pulses and shift pulses to FPS-16 radar.—Electronic Engineering Co., 601 East Chestnut Ave., Santa Ana, Calif.

CIRCLE 319 ON READER-SERVICE CARD

CODE SWITCH. 9-page Catalog 7300-A describes the Digiswitch a readout module for direct conversion from switch setting to special computer codes.—Digitran Co., a div. of the Endevco Corp., 660 S. Arroyo Parkway, Pasedena, Calif.

CIRCLE 320 ON READER-SERVICE CARD

VOLTAGE DIGITIZERS. 2-page Bulletin "What Adage Voldicons are Doing" describes the versatility of the all-semiconductor digitizers.—Adage, 292 Main St., Cambridge 42, Mass.

CIRCLE 321 ON READER-SERVICE CARD

DIGITAL INSTRUMENTATION. 6-page Bulletin 100-D gives brief specifications and features of d-c voltmeters, control units, preamplifiers, a-c converters, ohmmeters, ratiometers, scanning systems, printer control units, chronometer, and the Cubic talking meter.—Cubic Corp., 5575 Kearny Villa Rd., San Diego 11, Calif.

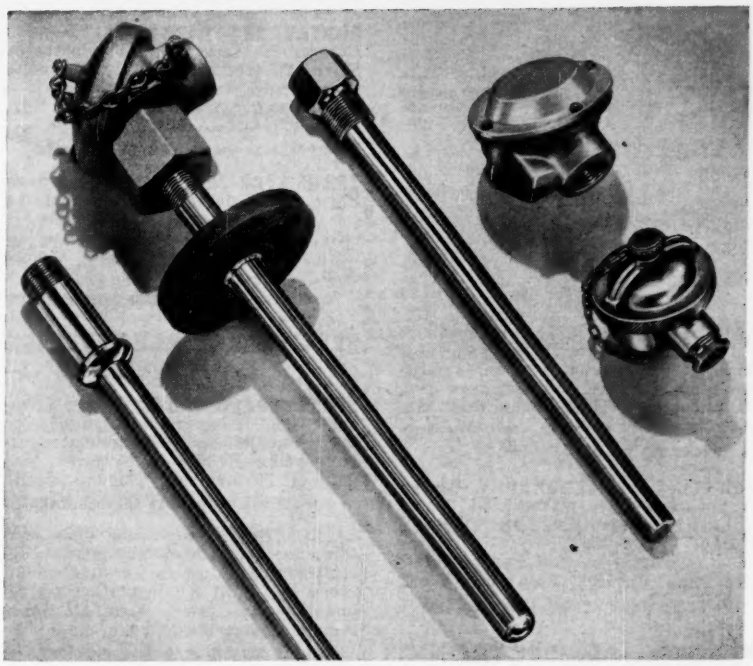
CIRCLE 322 ON READER-SERVICE CARD

DATA LINK CONVERTERS. 4-page Bulletin 125902 describes the high-speed Data Link Conversion system applied to either standard telephone or microwave link transmission media.—Epsco, Inc., Equipment Div., 275 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 323 ON READER-SERVICE CARD

TRANSISTORIZED TRANSLATOR. 2-page Bulletin 122 describes and specifies Model TR-702 gray-to-binary translator.—Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 324 ON READER-SERVICE CARD



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CIRCLE 146 ON READER-SERVICE CARD

ICS NEW LITERATURE

PHOTOELECTRIC TAPE READER. 2-page Data Sheet 2120 describes Model 100 photoelectric tape reader. —Photocircuits Corp., 31 Sea Cliff Ave., Glen Cove, N. Y.

CIRCLE 325 ON READER-SERVICE CARD

TESTING

TEST EQUIPMENT. 6-page Short Form Catalog illustrates and specifies 15 different precision electronic instruments to measure and test networks, calibrate receivers and generators, etc. —Boonton Radio Corp., Boonton, N. J.

CIRCLE 326 ON READER-SERVICE CARD

SAMPLING OSCILLOGRAPHY. 8-page Application Note 36 entitled "Sampling Oscillography" describes a method for pulse analysis of ultra fast circuits.—Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.

CIRCLE 327 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

TRANSDUCERS. 16-page Bulletin 1308 is a general catalog containing design details and applications of pressure instrumentation, force-balance instruments, unbonded strain-gage and potentiometer pressure transducers, vibration transducers, accelerometers, galvanometers, ceramic, and precision optical products.—Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasedena, Calif.

CIRCLE 328 ON READER-SERVICE CARD

PANEL METERS. 12-page Bulletin GEA-7034 offers information on line of 2½", 3½", and 4½" "Big Look" panel meters.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 329 ON READER-SERVICE CARD

NOISE ANALYSIS. 20-page Bruel & Kjaer "Technical Review" No. 4, 1959 describes the concepts of amplitude density analysis of non-periodic noise. —B & K Instruments, Inc., of 3044 West 160th St., Cleveland, Ohio.

CIRCLE 330 ON READER-SERVICE CARD

ELECTRONIC INSTRUMENTS. 6-page short-form Catalog 60 describes electronic filters, laboratory power amplifiers, wide-range RC oscillators, and regulated power supplies.—Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 331 ON READER-SERVICE CARD

DIFFERENTIAL TRANSFORMERS AND TRANSDUCERS. 16-page catalog illustrates and describes with specs equipment for mechanical measurements by electrical methods.—Daytronic Corp., 223-227 S. Jefferson St., Dayton 2, Ohio.

CIRCLE 332 ON READER-SERVICE CARD

CURRENT PULSE GENERATOR. 2-page Bulletin 59-G describes Model 1051 Millimicrosecond current pulse generator.—Rese Engineering, Inc., 731 Arch St., Phila. 6, Pa.

CIRCLE 333 ON READER-SERVICE CARD

DIGITAL INSTRUMENTS. 20-page Bulletin 20-1 describes and illustrates Series 20 transistorized digital voltmeters, ratiometers, and ohmeters.—Non-Linear Systems, Inc., Del Mar, Calif.

CIRCLE 334 ON READER-SERVICE CARD

TRANSISTORIZED CHOPPER. 4-page Form V383 describes and illustates the Chopperette solid-state transistorized chopper.—Victory Engineering Corp., 537 Springfield Rd., Union, N. J.

CIRCLE 335 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC COMPONENTS

SWITCHBOARD JACKS. 4-page Catalog J-102 describes telephone-type jacks and panels with schematic circuits and sketches.—Switchcraft, Inc., 5555 N. Elston Ave., Chicago 30, Ill.

CIRCLE 336 ON READER-SERVICE CARD

INSULATION. 2-page data sheet contains performance characteristics, description, and tables showing diameters of Ceron ST insulation on resistance-alloy wire.—Kanthal Corp., Amelia Place, Stamford, Conn.

CIRCLE 337 ON READER-SERVICE CARD

THERMAL TIME DELAY RELAYS. Folder contains 6 data sheets with information on engineering data for thermal delay relay applications.—Thermal Controls, Inc., 43 River Rd., North Arlington, N. J.

CIRCLE 338 ON READER-SERVICE CARD

MISCELLANEOUS

GAS ANALYSIS IN CEMENT KILNS. 4-page Performance Report G10.1-1 details improvements in the operation of three kilns and a waste heat boiler, resulting from the installation of a gas analyzer at a Michigan cement company.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 339 ON READER-SERVICE CARD

SMALL TUBING. 12-page Bulletin 42 summarizes the significant properties of 84 tubing analyses in seven groups: carbon steels, stainless steels, alloy steels, nickel and nickel alloys, copper base alloys, glass-sealing alloys, and reactive metals.—Superior Tube Co., Norristown, Penna.

CIRCLE 340 ON READER-SERVICE CARD

PIEZOELECTRIC CERAMICS. 4-leaflets describe and specify transducer elements and special ceramic services. —U. S. Sonics Corp., 625 McGrath Highway, Somerville 45, Mass.

CIRCLE 341 ON READER-SERVICE CARD

STEAM-WATER SERVICE. Manual contains 22 sheets with typical examples, offering workable systems to solve water-steam control problems.—Powers Regulator Co., 3434 Oakton St., Skokie, Ill.

CIRCLE 342 ON READER-SERVICE CARD

RECORDER ACCESSORIES. 4-page folder describes chart papers, writing styli, etc. for all direct-writing recording equipment, and contains samples of chart papers.—Brush Instruments, Div. of Clevite Corp., 37th and Perkins, Cleveland 14, Ohio.

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ICS SEARCHLITE SECTION

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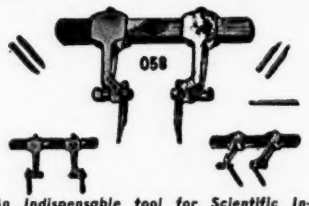

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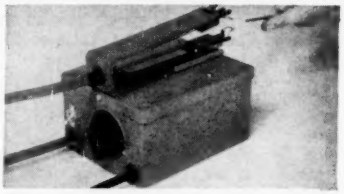

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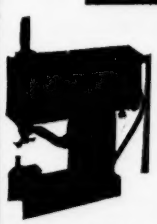
MINIATURE WELDERS



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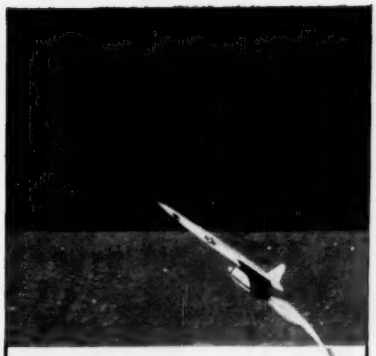

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CIRCLE 154 ON READER-SERVICE CARD

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Air Products Incorporated 1065
American Chain & Cable Company, Inc., Helicoid Gage Division 1041
American Meter Company, Incorporated 903, 1024
Amperite Co. Inc. 916
Annin Company 1005
ARCCO Instrument Company, Inc. 1035
Automatic Electric 913
Autonetics-Div. of North American Aviation, Inc. 909

Bacharach Industrial Instrument Company 918
Bailey Meter Company 960
Barber-Colman Company, Wheelco Instruments Division 991
Barksdale Valves 931
Bellofram Corporation 927
Bendix Corporation 1023
Berkeley Division, Beckman Instruments, Inc. 1014
Bird & Co., Inc., Richard H. 1029
Bristol Company 950
Brooks Rotameter Company 1030
Brush Instruments Division of Clevite Corporation 929, 930

Cambridge Instrument Company, Inc. 1031
Clevite Corporation, Brush Instruments Division 929, 930
Computer Measurements Co. 901
Computer Systems, Inc. 1016
Conoflow Corporation 1043
Consolidated Electrodynamics 1022
Control Data Corporation 957
Crescent Insulated Wire & Cable Co., Inc. 946

Dahl Company, Inc., George W. 1029
Davis Instruments 1049
Delavan Manufacturing Company 995
Dynametrics Corporation 918

Electro Instruments, Inc. ..... Outside Back Cover
Electro Switch Corp. 1055
Electro-Mech Corp. 943
Electronic Associates, Inc. 1012
Emery Company, A. H. 1053
Eppley Laboratory, Inc. 922
Erie Pacific Div. of Erie Resistor Corp. 908
Esterbrook Pen Company 1049
Esterline-Angus Company 1032
Ewald Instruments 1065

Fenwal Incorporated 978
Fisher Governor Company 964, 965
Flow Corporation 1062
Foxboro Company 971, 987
Freed Transformer Co., Inc. 1044

GPE Controls, Inc. ..... Inside Front Cover
General Kinetics Corp. 1047
General Motors Corporation, New Departure Division 915
Gould Co., J. D. 944
Gow-Mac Instrument Company 1050
Graphic Controls Corporation 926
Green Instrument Co., Inc. 943
Gubelman Charts Incorporated 938

Hagan Chemicals & Controls, Inc. 961
Hastings-Raydist, Inc. 1048
Hays Corporation 905
Heise Bourdon Tube Company, Inc. 1045
Helicoid Gage Division, American Chain & Cable Company, Inc. 1041
Houston Instrument Corporation 1037
Hydromatics, Inc. 999, 1000

Ideal Industries, Inc. 932
Illinois Testing Laboratories, Inc. 948
Imperial Brass Mfg. Co. 907
Industrial Electronic Engineers, Inc. 1054
Industrial Instruments Inc. 1037
InstruLab, Inc. 1030

Jamesbury Corp. 904
Jerguson Gage & Valve Company 1026
Johnson-Williams, Inc. 1052
Jones Optical Works, A. D. 948

Kanthal Corporation 944
Kearfott Division General Precision, Inc. 1057
Kernco Instruments Co., Inc. 1065
Klipfel Valves Incorporated 1040
Krohn-Hite Corporation 1051

Laboratory for Electronics, Inc. 1020
Lewis Engineering Co. 897
Ludlow Papers 1050
Lynn, Robert M. 1064

Macbeth Sales Corporation 982
Manning, Maxwell & Moore, Inc. 913, 919, 942, 1010
Marsh Instrument Company, Division of Colorado Oil and Gas Corporation 1054
Marshalltown Mfg. Company 918
Martin-Decker Corporation 936
Marx Co., Clarence J. 1065
Mason Instrument Company 1064
MASSA a Division of Cohu Electronics, Inc. 906
Mercoid Corporation 1040
Minneapolis-Honeywell Regulator Co. 910, 920, 921, 933, 940, 941, 956, 976, 977, 983
Moore & Company, Samuel 924
Moser Jewel Company 938

Nash Engineering Company 911
Neptune World-Wide Moving 923
Non-Linear Systems, Inc. 1036
North American Aviation, Inc., Missile Division 1065

P. B. R. Mfg. Co. 1061
PIC Design Corp. 1052
Pace Engineering Company 1052
Palmer Thermometers, Inc. 1036
Parabam, Inc. 1042
Philadelphia Scientific Glass Co. 1065
Post Electronic Products Division of Reid Brothers Company, Inc. 1056
Precision Tube Company 1044

Radiation Electronics Co. 1027
Radio Frequency Laboratories, Inc. 902
Renick Co., L. C. 1054
Research Incorporated 1026
Revere Corporation of America 1059
Rockwell Manufacturing Company 917
Rosemount Engineering Company 1058
Royal McBee Corporation 1018

Scam Instrument Corp. 1066
Scherr-Tumico 948
Seegers Instrument Company 1031
Sensitive Research Instrument Corporation 898
Shore Instrument & Mfg. Co., Inc. 1056
Skydyne, Inc. ..... Inside Back Cover
Standard Instrument Corp. 948
Stearns Electric Corporation 936
Stevens-Arnold Incorporated 1046
Strahman Valves, Inc. 1046
Superior Tube Company 949
Swartwout Division, Crane Co. 935
Swiss American Jewel Bearings Co. 1061
Synchro-Start Products 944

Technique Associates 986
Tektronix, Inc. 1060
Teletype Corporation 939
Thermo Electric Co., Inc. 1063

Ultrasonic Industries Inc. 1056
Unertl Optical Co., John 1058
Uniflow Valve Corporation 1058
United Electric Controls Company 934
Universal Relay Corp. 1061

Valcor Engineering Corp. 1031
Varian Associates 1047

Wallace & Tiernan Incorporated 1038, 1039
Watch Stones Co. Ltd. Thun 986
Welch Scientific Company, W. M. 1025
Western Electronic Products Co. 1064
Weston Instruments Div. of Daystrom, Inc. 937, 945
Westronics, Inc. 947
Wheeler Manufacturing Co., C. H 982
Worley Jewel Co., John 1062

Zeiss, Inc., Carl 986

PRODUCT INDEX

The following is a handy reference to products (and their reader-service number) reported in this issue. For more information on any product mentioned, circle the corresponding number on the reader-service card at the right.

This index is published as a service. Every care is taken to make it accurate, but I&CS assumes no responsibility for errors or omissions.

Accelerometer, 9, 265
Air Cylinder, 281
Air Dryer, 235
Ammeter, 191
Amplifier, 166, 170, 196, 212, 290
Anemometer, 144
Annunciator, 154, 175, 274
An/Dig. Encoder, 179, 258
Battery, 286
Beam Sw. Tube, 269
Bearings, 176
Boiler Control, 61
Brake, 36, 192
Bridge, 250
Calibrator, 3
Camera, 228
Channel Analyzer, 251
Chart, 28, 122
Chart Drive, 18
Chopper, 114, 335
Clutches, 36, 192
Compression Test, 224
Computer, Analog, 79, 80, 81, 168
Computer, Digital, 59, 82, 85, 167, 315
Conductivity, 103
Controller, 27, 35, 56, 221, 263
Conversion Factors, 169
Counter, Electronic, 4, 11, 285
Counters, 310
Current Regulator, 17
Data Reducion, 5, 277, 298, 314, 319, 320, 323, 324
Diaphragm, 12
Digital Clock, 109
Digital Modules, 155, 238, 249, 321, 322, 334
Digital Readout, 130, 220, 234
Displacement Trans., 236, 332
Electronic Test, 326
Engine Control, 223
Engraver, 44
Environmental Chamber, 197, 229, 266
Flame-out, 74
Flowmeter, 6, 93, 259, 305
Gas Analyzer, 23, 96, 120, 121, 124, 339
Gas Sampler, 99
Gears, 126
Geneva Drive, 268
Hardness Tester, 134
Hydrogen Detector, 218
Infrared, 240
Ink Pen, 119
Insulation Leak, 337
Integrator, 248
Jacks, 336
Jewels, 39, 91, 141, 145
Key Spanner, 147
Laboratory Standard, 3
Leak Detector, 14, 173
Level, 13, 86, 88, 110, 194, 296, 306
Magnetic Amplifier, 203
Magnetic Tape, 245, 316
Mass Spectrom., 288
Memory Disc, 83, 195
Memory Tester, 246
Micro Projector, 51
Microscope, 256, 295
Microscope, Stereo, 70
Monitor, 318
Motor Control, 199, 225, 242, 278
Motor-Generator, 135
Nitrogen Analyzer, 275
Noisemeter, 330
Optics, 52, 137
Oscilloscope, 201, 211, 222
Oven, 213
Panel Light, 253
Panel Meters, 329
Panels, 241
Paper Tape, 255
Particle Counter, 252
pH, 64
Phase Shifter, 283
Photocopy, 232
Photoelectric, 132, 297
Piezoelectric, 341
Power Supply, 123, 174, 202, 243, 289, 233, 331
Pressure Controller, 57, 86, 107, 182, 231, 267
Pressure Gage, 13, 24, 37, 42, 57, 104, 108, 113, 115, 128, 171, 219, 292, 307
Pressure Standard, 22, 219
Pressure Switch, 31, 287
Pressure Transducer, 84, 110, 125, 194, 244, 262, 273, 328
Process Control, 6, 21, 27, 35, 41, 43, 56, 61, 272
Programmer, 89
Pulse Gen., 333
Pump, 105, 291
Pyrometer, 53, 72, 148
Ratemeter, 172
Recorder, 21, 50, 60, 65, 89, 98, 116, 214, 217, 307, 312, 317, 343
Relays, 33, 143, 206
Resistor, 207, 226
Scaler, 172, 251
Scales, 129
Scanner, 215
Scope Dolly, 142
Shipping, 25
Soldering, 32
Sound, 9
Speed, 313
Speed Switch, 46
Standard Cell, 19
Steam, 342
Stopwatch, 311
Strain Gage, 140, 239
Stunt Box, 181, 198
Switch, 2, 139
Tachometer, 152, 153, 264
Telemeter, 40
Temperature Alarm, 287
Temperature Control, 34, 48, 58, 66, 78, 227, 303
Temperature Indicator, 90, 190, 193, 304
Temperature Trans., 73
Thermocouple, 2, 47, 146, 180, 209, 257, 270, 302
Thermometer, 101, 138, 216, 254, 293
Thermostat, 150
Time Delay, 17, 338
Timers, 204, 230
Tubes, 269, 284
Tubing, 49, 111, 340
Tubing, Capillary, 55
Ultrasonic Cleaner, 133
Ultrasonic Test, 189
Vacuum, 87, 271, 279
Valve Actuators, 1, 68, 260, 278, 294
Valve, Ball, 7, 178, 237, 260
Valve Check, 261
Valve, Control, 41, 77, 117, 276
Valve, Safety, 20
Valve, Sampling, 247
Valve, Solenoid, 45, 95 300, 301
Valves, 92, 106, 205, 208, 210, 279, 299,
Volt./Freq. Conv., 200
Voltmeter, 3, 100, 155, 191, 238, 280, 282, 321, 334
Weighing, 127, 239, 308, 309
Welder, 151
Xenon Lamp, 67
X-Y Plotter, 102, 177

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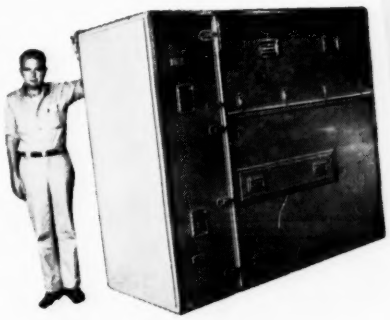

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